NRRB Site Information Package for ROD Amendment
West Lake Landfill Operable Unit 1
Bridgeton, Missouri
MOD079900932
Site charging code: 0714BD01

A. Site Summary

The West Lake Landfill Site is on a parcel of approximately 200 acres located in the northwestern portion of the St. Louis metropolitan area (**Figure 1-1**). It is situated approximately one mile north of the intersection of Interstate 70 and Interstate 270 within the limits of the city of Bridgeton in northwestern St. Louis County. The Missouri River lies about two miles to the north and west of the Site. The Site is bounded on the north by St. Charles Rock Road and on the east by Taussig Road. Old St. Charles Rock Road borders the southern and western portions of the Site. The Earth City Industrial Park is adjacent to the Site on the west. The Spanish Village residential subdivision is located less than a mile to the south and a trailer park is less than a mile to the southeast (**Figure 1-2**).

The Site consists of the Bridgeton Sanitary Landfill (Former Active Sanitary Landfill) and several inactive areas with sanitary and demolition fill that have been closed. The address of the Bridgeton Landfill is 13570 St. Charles Rock Road. Land use at the site and the surrounding areas in Earth City is industrial.

Other facilities which are not subject to this response action are located on the 200-acre parcel including concrete and asphalt batch plants, a solid waste transfer station, and an automobile repair shop.

The Site was used agriculturally until a limestone quarrying and crushing operation began in 1939. The quarrying operation continued until 1988 and resulted in two quarry pits. Beginning in the early 1950s, portions of the quarried areas and adjacent areas were used for landfilling municipal solid waste (MSW), industrial solid wastes, and construction/demolition debris. These operations were not subject to state permitting because they occurred prior to the formation of the Missouri Department of Natural Resources (MDNR) in 1974. Two landfill areas were radiologically contaminated in 1973 when they received soil mixed with leached barium sulfate residues.

The barium sulfate residues, containing traces of uranium, thorium, and their long-lived daughter products, were some of the uranium ore processing residues initially stored by the Atomic Energy Commission (AEC) on a 21.7-acre tract of land in a then undeveloped area of north St. Louis County, now known as the St. Louis Airport Site (SLAPS), which is part of the St. Louis Formerly Utilized Sites Remedial Action Program managed by the U.S. Army Corps of Engineers.

In 1966 and 1967, the remaining residues from SLAPS were purchased by a private company for mineral recovery and placed in storage at a nearby facility on Latty Avenue under an AEC license. Most of the residues were shipped to Canon City, Colorado, for reprocessing except for the leached barium sulfate residues, which were the least valuable in terms of mineral content, i.e., most of the uranium and radium was removed in previous precipitation steps. Reportedly, 8,700 tons of leached barium sulfate residues were mixed with approximately 39,000 tons of soil and then transported to the Site. According

30286008

to the landfill operator, the soil was used as cover for municipal refuse in routine landfill operations. The data collected during the Remedial Investigation (RI) are consistent with this account.

The quarry pits were used for permitted solid waste landfill operations beginning in 1979. In August 2005, the Bridgeton Sanitary Landfill (Former Active Sanitary Landfill) stopped receiving waste pursuant to a restrictive covenant with the Lambert - St. Louis Airport to reduce the potential for birds to interfere with airport operations.

EPA placed the Site on the Superfund National Priorities List (NPL) in 1990. In 1993, EPA entered into an Administrative Order on Consent (AOC) with the potentially responsible parties (PRPs) for performance of the OU 1 RI/Feasibility Study (FS). Pursuant to the requirements of that order, the PRPs submitted for EPA's review and approval an RI which detailed the findings of extensive sampling and analysis on the area of OU 1 and the surrounding area. Following the RI, the PRPs submitted for EPA's review and approval an FS which evaluated the various remedial alternatives for OU 1 consistent with the requirements of the AOC and taking into account the requirements of CERCLA and the NCP. In addition, the state of Missouri was provided an opportunity for review and comment on these documents. The FS was approved in early 2006.

The proposed plan was released in June 2006, and the first public comment period ran until December 2006. The second public comment period ran in early 2008 after extensive HQ review of the proposed plan, and the ROD was signed in May 2008. A vocal minority of St. Louis residents sent two letters to EPA HQ in 2009 requesting that HQ re-evaluate the Region's decision. HQ issued a one-page memorandum after the first letter, but in December 2009 decided to undertake a Supplemental Feasibility Study (SFS) after the second letter. The SFS was completed in December 2011. Based on the SFS analysis, the Region briefed the OSWER AA on its proposed decision in January 2012.

The Site is divided into the following areas (**Figure 4-1**):

• Radiological Area 1 – This area was part of the landfill operations conducted prior to state regulation. Approximately 10 acres are impacted by radionuclides at depths ranging up to 15 feet. The radionuclides are in soil material that is intermixed with the overall landfill matrix consisting of municipal refuse.

• Radiological Area 2 – This area was also part of the unregulated landfill operations conducted prior to 1974. Approximately 30 acres are impacted by radionuclides at depths generally ranging to 12 feet, with some localized occurrences that are deeper. The radionuclides are in soil material that is intermixed with the overall landfill matrix consisting mostly of construction and demolition debris.

• Buffer Zone/Crossroad Property – This property—also known as the Ford Property—lies west of Radiological Area 2 and became surficially contaminated when erosion of soil from the landfill berm resulted in transport of radiologically contaminated soils from Area 2 onto the adjacent property.

• Closed Demolition Landfill – This area is located on the southeast side of Radiological Area 2. This landfill received demolition debris. It received none of the radiologically contaminated soil. It operated under permit with the state and was closed in 1995.

• Inactive Sanitary Landfill – This landfill is located south of Radiological Area 2 and was part of the unregulated landfill operations conducted prior to 1974. The landfill contains sanitary wastes and a variety of other solid wastes and demolition debris. It received none of the radiologically contaminated soil.

• Former Active Sanitary Landfill – This municipal solid waste landfill—known as the Bridgeton Landfill—is located on the south and east portions of the Site. The landfill is subject to a state permit issued in 1974. This landfill received none of the radiologically contaminated soil. This landfill ceased operation in 2005.

The Site has been divided into two OUs. OU 1 consists of Radiological Area 1 and Radiological Area 2 (Areas 1 and 2) and the Buffer Zone/Crossroad Property. OU 2 consists of the other landfill areas that are not impacted by radionuclides, i.e., the Closed Demolition Landfill, the Inactive Sanitary Landfill, and the Former Active Sanitary Landfill.

Risk Summary

Evaluation Criteria	**ROD-Selected Remedy**	**"Complete Rad Removal" with Off-site Disposal**	**"Complete Rad Removal" With On-site Disposal**
Primary Balancing Criteria			
Long-Term Effectiveness and Permanence			
Magnitude of residual risks	Highest long-term risk that would remain upon completion of the remedial action (1.3×10^{-5}) is within EPA's target risk range of 1×10^{-6} to 1×10^{-4}.	Highest long-term risk that would remain upon completion of the remedial action ($<1 \times 10^{-7}$) is less than EPA's target risk range of 1×10^{-6} to 1×10^{-4}.	Highest long-term risk that would remain upon completion of the remedial action (1.5×10^{-5}) is within EPA's target risk range of 1×10^{-6} to 1×10^{-4}.
Short-Term Effectiveness			
Protection of the community during any remedial action	Lowest potential for impacts to the community: Transportation accident incidence:0.61 Carcinogenic risk to residents:3.3×10^{-6} Carbon dioxide emissions: 8,350 tons	Highest potential for impacts to the community: Transportation accident incidence:1.4 Carcinogenic risk to residents:2.1×10^{-5} Carbon dioxide emissions: 35,400 tons	Lower potential for impacts to the community: Transportation accident incidence:0.79 Carcinogenic risk to residents:2.0×10^{-5} Carbon dioxide emissions: 17,900 tons
		Excavation of RIM would create depressions in the waste where precipitation could accumulate increasing the potential for infiltration, leaching and creation of a plume of contamination in groundwater.	Excavation of RIM would create depressions in the waste where precipitation could accumulate increasing the potential for infiltration, leaching and creation of a plume of contamination in groundwater.
	This alternative poses the least potential for increased bird strikes to aviation operations at nearby Lambert-St. Louis International Airport.	This alternative poses potential for increased bird strikes to aviation operations at nearby Lambert-St. Louis International Airport.	This alternative poses greatest potential for increased bird strikes to aviation operations at nearby Lambert-St. Louis International Airport.
Protection of workers during remedial actions	Lowest potential for impacts to workers Industrial accident incidence – 4.7 Carcinogenic risk – 7.2×10^{-5} Worker dose (TEDE) – 50 mrem/yr	Greater potential impacts to workers from increased handling of RIM Industrial accident incidence – 7.6 Carcinogenic risk – 7.6×10^{-4} Worker dose (TEDE) – 260 mrem/yr	Greater potential impacts to workers due to increased handling of RIM Industrial accident incidence – 9.0 Carcinogenic risk – 7.4×10^{-4} Worker dose (TEDE) – 260 mrem/yr

RAOs and Cleanup Levels

RAOs for Areas 1 and 2 of OU 1

• Prevent direct contact with landfill contents including exposure to external radiation
• Minimize infiltration and any resulting contaminant leaching to groundwater
• Control surface water runoff and erosion
• Control and treat landfill gas emissions including radon

RAOs for Buffer Zone/Crossroad Property portion of OU1
• Prevent direct contact with contaminated surface soils or ensure contaminant levels are low enough to allow for unlimited use and unrestricted exposure.

There are no cleanup standards set for soil or groundwater at the site. The radiologically impacted material is confined to the MSW within the landfill. No plume of contaminated groundwater is present at the site.

Description of Alternatives

Remedial alternatives were evaluated in two phases: the 2006 Feasibility Study and the 2011 Supplemental Feasibility Study (SFS). The 2011 SFS re-evaluated *in greater detail* two of the remedies from the 2006 FS (cap-in-place and excavation with off-site disposal), and added a detailed evaluation excavation with on-site disposal in a new engineered landfill cell. The costs and timeframes calculated in the SFS for these three remedies are as follows:

Remedy	Cap-in-Place Remedy	Excavate and Off-site Disposal	Excavate and On-site Disposal
Cost (unconstrained):	$41.4M	$259-$415M	$137M
Time to construct:	3 years	4 years	6 years

Preferred Alternative

Based on the analysis performed in the SFS, Region 7 will re-select the ROD-selected remedy of capping the radiologically-contaminated MSW in place with a hybrid cap meeting MDNR, RCRA Subtitle D, and UMTRCA design standards; consolidation of material from the Buffer Zone into Area 2; landfill gas monitoring and control as necessary; institutional controls; long-term cover maintenance; and long-term groundwater monitoring on- and off-site.

Stakeholder Views

MDNR provided the following statement describing state acceptance of the ROD remedy:
"The Missouri Department of Natural Resources has reviewed the Record of Decision for Operable Unit 1 and Operable Unit 2 (OU 1 and OU 2) of the West Lake Landfill. Generally speaking, everyone would want all sites remediated to levels that provide unencumbered use. The department's goal of remediation to unencumbered use aligns with the National Contingency Plan's objective. For West Lake Landfill, however, the department accepts remediation that provides containment and isolation of contaminants from human receptors and the environment as the most reasonable option given the circumstances, as defined in the selected remedies for OU 1 and OU 2. The department recognizes the hazards associated with excavation into a former solid waste landfill, and has determined that the risks associated with this option to on-site workers and nearby citizens, outweigh the risks of containment in place.

The department also recognizes the need for long-term care and monitoring for containment in place and insists that a robust and durable stewardship plan be implemented to address this aspect. In order to achieve this, the state has applicable standards, which are relevant and appropriate for:
• closure and long-term care of all portions of the Site,
• monitoring and control of gas generated in the waste deposits,
• monitoring of groundwater, and
• continued removal of leachate from the formerly active sanitary landfill.

The department must remain a partner in the development of the remedial design, stewardship plan, and implementation of these aspects for this Site to ensure that the Selected Remedy remains protective of human health and the environment into the future. To reiterate, the department would support actions that move the Site closer to unencumbered use (recognizing the Site is a landfill), should future events occur that would change the current administrative process."

Many community activists, local officials, and others expressed a preference for moving the radiologically contaminated waste to another disposal facility. Common concerns included the Site being located in a flood plain and protection of the water supply. Many who live and work in proximity to the Site expressed a preference for managing the waste in place. A common concern was that excavation might result in a release of contaminated dust. All significant public comments and EPA responses are provided in the Responsiveness Summary attached to this ROD.

The Lambert - St. Louis Airport is opposed to both of the dig-and-haul remedies evaluated in the SFS and provided EPA a letter stating their position.

B. Detailed Information

The West Lake Landfill Site (Site) is located in Bridgeton, Missouri. The U.S. Environmental Protection Agency (EPA) is the lead agency, and the Missouri Department of Natural Resources (MDNR) is the supporting state agency. The EPA ID Number is MOD079900932.

The Site is on a parcel of approximately 200 acres located in the northwestern portion of the St. Louis metropolitan area (**Figure 1-1**). It is situated approximately one mile north of the intersection of Interstate 70 and Interstate 270 within the limits of the city of Bridgeton in northwestern St. Louis County. The Missouri River lies about two miles to the north and west of the Site. The Site is bounded on the north by St. Charles Rock Road and on the east by Taussig Road. Old St. Charles Rock Road borders the southern and western portions of the Site. The Earth City Industrial Park is adjacent to the Site on the west. The Spanish Village residential subdivision is located less than a mile to the south (**Figure 1-2**).

The Site consists of the Bridgeton Sanitary Landfill (Former Active Sanitary Landfill) and several inactive areas with sanitary and demolition fill that have been closed. The address of the Bridgeton Landfill is 13570 St. Charles Rock Road. The Site is divided into two operable units (OUs). OU 1 addresses two of the inactive landfill areas that are radiologically contaminated known as Area 1 and Area 2, and the area formerly described as the Ford Property, now the Buffer Zone/Crossroads Property. The other landfill areas that are not impacted by radionuclide contaminants are addressed by OU 2.

Other facilities which are not subject to this response action are located on the 200-acre parcel including concrete and asphalt batch plants, a solid waste transfer station, and an automobile repair shop.

Site History and Enforcement Activities

The Site was used agriculturally until a limestone quarrying and crushing operation began in 1939. The quarrying operation continued until 1988 and resulted in two quarry pits. Beginning in the early 1950s, portions of the quarried areas and adjacent areas were used for landfilling municipal refuse, industrial solid wastes, and construction/demolition debris. These operations were not subject to state permitting because they occurred prior to the formation of MDNR in 1974. Two landfill areas were radiologically contaminated in 1973 when they received soil mixed with leached barium sulfate residues.

The barium sulfate residues, containing traces of uranium, thorium, and their long-lived daughter products, were some of the uranium ore processing residues initially stored by the Atomic Energy Commission (AEC) on a 21.7-acre tract of land in a then undeveloped area of north St. Louis County, now known as the St. Louis Airport Site (SLAPS), which is part of the St. Louis Formerly Utilized Sites Remedial Action Program managed by the U.S. Army Corps of Engineers (Corps). The radium and lead-bearing residues—known as K-65 residues—were stored in drums prior to being relocated to federal facilities in New York and Ohio.

In 1966 and 1967, the remaining residues from SLAPS were purchased by a private company for mineral recovery and placed in storage at a nearby facility on Latty Avenue under an AEC license. Most of the residues were shipped to Canon City, Colorado, for reprocessing except for the leached barium sulfate residues, which were the least valuable in terms of mineral content, i.e., most of the uranium and radium was removed in previous precipitation steps. Reportedly, 8,700 tons of leached barium sulfate residues were mixed with approximately 39,000 tons of soil and then transported to the Site. According to the landfill operator, the soil was used as cover for municipal refuse in routine landfill operations. The data collected during the Remedial Investigation (RI) are consistent with this account.

The quarry pits were used for permitted solid waste landfill operations beginning in 1979. In August 2005, the Bridgeton Sanitary Landfill (Former Active Sanitary Landfill) stopped receiving waste pursuant to an agreement with the city of St. Louis to reduce the potential for birds to interfere with airport operations.

EPA placed the Site on the Superfund National Priorities List (NPL) in 1990. The NPL is a list of priority sites promulgated pursuant to section 105 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, as amended. The NPL is found in Appendix B of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP).

In 1993, EPA entered into an Administrative Order on Consent (AOC) with the potentially responsible parties (PRPs) for performance of the OU 1 RI/Feasibility Study (FS). The PRPs for OU1 are Cotter Corporation (N.S.L); Laidlaw Waste Systems (Bridgeton), Inc.; Rock Road Industries, Inc.; and the US Department of Energy. Pursuant to the requirements of that order, the PRPs submitted for EPA's review and approval an RI which detailed the findings of extensive sampling and analysis on the area of OU 1 and the surrounding area. Following the RI, the PRPs submitted for EPA's review and approval an FS which evaluated the various remedial alternatives for OU 1 consistent with the requirements of the AOC and taking into account the requirements of CERCLA and the NCP. In addition, the state of Missouri was provided an opportunity for review and comment on these documents. The FS was approved in early 2006.

The proposed plan was released in June 2006, and the first public comment period ran until December 2006. The second public comment period ran in early 2008 after extensive HQ review of the proposed plan, and the ROD was signed in May 2008. A vocal minority of St. Louis residents sent two letters to EPA HQ in 2009 requesting that HQ re-evaluate the Region's decision. HQ issued a one-page memorandum after the first letter, but in December 2009 decided to undertake a Supplemental Feasibility Study (SFS) after the second letter. The SFS was completed in December 2011. Based on the SFS analysis, the Region briefed the OSWER AA on its proposed decision in January 2012.

Scope and Role of Operable Unit or Response Action

The Site is divided into the following areas (see **Figure 4-1**):

• Radiological Area 1 – This area was part of the landfill operations conducted prior to state regulation. Approximately 10 acres are impacted by radionuclides at depths ranging up to 15 feet. The radionuclides are in soil material that is intermixed with the overall landfill matrix consisting of municipal refuse.

• Radiological Area 2 – This area was also part of the unregulated landfill operations conducted prior to 1974. Approximately 30 acres are impacted by radionuclides at depths generally ranging to 12 feet, with some localized occurrences that are deeper. The radionuclides are in soil material that is intermixed with the overall landfill matrix consisting mostly of construction and demolition debris.

• Buffer Zone/Crossroad Property – This property—also known as the Ford Property—lies west of Radiological Area 2 and became surficially contaminated when erosion of soil from the landfill berm resulted in transport of radiologically contaminated soils from Area 2 onto the adjacent property.

• Closed Demolition Landfill – This area is located on the southeast side of Radiological Area 2. This landfill received demolition debris. It received none of the radiologically contaminated soil. It operated under permit with the state and was closed in 1995.

• Inactive Sanitary Landfill – This landfill is located south of Radiological Area 2 and was part of the unregulated landfill operations conducted prior to 1974. The landfill contains sanitary wastes and a variety of other solid wastes and demolition debris. It received none of the radiologically contaminated soil.

• Former Active Sanitary Landfill – This municipal solid waste landfill—known as the Bridgeton Landfill—is located on the south and east portions of the Site. The landfill is subject to a state permit issued in 1974. This landfill received none of the radiologically contaminated soil. This landfill ceased operation in 2005.

The Site has been divided into two OUs. OU 1 consists of Radiological Area 1 and Radiological Area 2 (Areas 1 and 2) and the Buffer Zone/Crossroad Property. OU 2 consists of the other landfill areas that are not impacted by radionuclides, i.e., the Closed Demolition Landfill, the Inactive Sanitary Landfill, and the Former Active Sanitary Landfill. The OU 1 and OU 2 RODs provide the final remedial actions for both source control and groundwater and complete the CERCLA decision-making for the Site. Capping in place is the selected remedy for the OU2 landfill cells pursuant to a separate 2008 ROD. The construction of the OU1 and OU2 caps must be coordinated as the earthwork for the two caps will intersect due to their proximity. The future use of OU1 and OU2 is as a landfill for the foreseeable future; no redevelopment will be possible due to long-term maintenance requirements and restrictive covenants.

Site Characteristics

Illustrations of the Site conceptual model are depicted in **Figures 5-1 and 5-2**. Both radionuclide and nonradionuclide contaminants have been investigated.

The following pathways have been investigated:
• Airborne transport of radon gas and fugitive dust;
• Rainwater runoff transport of dissolved or suspended contaminants;
• Erosion and transport of contaminated soils; and
• Leaching of contaminants to the underlying alluvial groundwater.

Overview of Site Conditions and Land Use

The Site is located within the western portion of the St. Louis metropolitan area on the east side of the Missouri River. The landfill is situated approximately one mile north of the intersection of Interstate 70 and Interstate 270 within the city limits of the city of Bridgeton in northwestern St. Louis County. St. Charles Rock Road (State Highway 180) borders the landfill on the north. Taussig Road and agricultural land lie southeast of the landfill. Old St. Charles Rock Road, along with undeveloped land, borders the southern and western portions of the landfill (**Figure 1-2**).

The Site is an approximately 200-acre parcel containing multiple landfill cells and other facilities. The primary facility—the Bridgeton Landfill (formerly known as the Laidlaw Landfill)—has an address of 13570 St. Charles Rock Road, St. Louis County, Missouri. The Bridgeton Landfill, referred to herein as the Former Active Sanitary Landfill, stopped receiving waste in 2005 and is now in post-closure status. Other facilities on the Site that are not the subject of the CERCLA action include the concrete and asphalt batch plants, an automotive repair shop, and a waste transfer station. The Site's layout is shown in **Figure 4-1**.

Land use in the area surrounding the landfill is commercial and industrial. Deed restrictions have been recorded against the entire Site to prevent residential development or groundwater use from occurring at the landfill. Additional deed restrictions have been recorded against Areas 1 and 2 to prevent construction of buildings or utility excavations in these areas. The southernmost portion of the landfill property is permitted for active sanitary landfill operations (Permit No. 118912). The property to the north of the landfill across St. Charles Rock Road is moderately developed with commercial, retail, and manufacturing operations. The Earth City Industrial Park is located adjacent to the landfill on the west, across Old St. Charles Rock Road. The nearest residential development, Spanish Village, is located to the south of the landfill near the intersection of St. Charles Rock Road and Interstate 270 approximately 0.75 mile from Area 1 and 1 mile from Area 2. Mixed commercial, retail, manufacturing, and single-family residential uses are present to the southeast of the landfill.

Surface Features

The Site is situated on the eastern edge of the Missouri River flood plain approximately two miles east of the river. The river is separated from the area of the Site by a levee system. Ground elevations at the Site range from approximately 450 to 500 feet; however, the topography of the Site area has been significantly altered by quarry activities in the eastern portion of the landfill and by placement of mine spoils and landfill materials in the eastern and western portion of the landfill.

Area 1 is situated on the north and western slopes of a topographic high within the landfill. Ground surface elevation in Area 1 varies from 490 feet on the south to 452 feet at the roadway near the landfill property entrance. Area 1 consists of approximately 10 acres.

Area 2 is situated between a topographic high of landfilled materials on the south and east and the Buffer Zone and Crossroad Properties (former Ford Property) on the west. The highest topographic level in Area 2 is about 500 feet on the southwest side of Area 2 sloping to approximately 470 feet near the top of the landfill berm along the south side of the Ford Property. The upper surface of the berm along the western edge of Area 2 is located approximately 20 to 30 feet above the adjacent Ford Property and approximately 30 to 40 feet higher than the water surface in the flood control channel located to the southwest of Area 2. A berm on the northern portions of Area 2 controls runoff to the adjacent properties. Area 2 consists of approximately 30 acres.

On the north side of Area 2 is the property referred to as the Buffer Zone/Crossroad Property (called the Ford Property in the RI). This property was previously owned by Ford Motor Credit, Inc. (Ford). Prior to 1998, Ford subdivided and sold all of its property in this area. The majority of the Ford Property was sold to Crossroad Properties LLC and has been developed into the Crossroad Industrial Park. Ford retained the 1.78 acres immediately adjacent to the western portion of the northern boundary of Area 2 referred to as the Buffer Zone. The ownership of the Buffer Zone was subsequently acquired by Rock Road Industries, Inc. (Rock Road) on behalf of the landfill owner.

Earth City Levee District

The Site borders the Earth City Levee District to the east, with the northwestern edge of the Site located about one and one third mile from the Missouri River. The Earth City Levee District is fully developed with business and industrial parks. The 1,891-acre Levee District is protected on three sides with the main levee running 2.6 miles along the eastern bank of the Missouri River. The levee system is designed to exceed the 500-year flood level and ranges from 462.03 feet above mean sea level (ft/amsl) at the south end to 459.34 ft/amsl at the north end. The 500-year flood elevations at these locations are 459.03 ft/amsl and 452.15 ft/amsl, respectively. Assuming a 500-year flood, the Missouri River would be three to seven feet below the top of the Earth City levee.

Landfilling at the Site has significantly raised the elevation of Areas 1 and 2 above the level of the former flood plain. The top elevation of the Area 2 berm is approximately 20 feet above the projected flood elevations of about 453 feet within the levee system along the river. Flooding of areas adjacent to the landfill, i.e., areas outside of the levee system, would only occur as a result of a failure of the levee system. Spreading of floodwaters into areas outside of the levee system would result in lower flood elevations than those projected to occur within the levee system. Therefore, the actual elevations of any floodwaters that may extend into areas adjacent to the landfill would be less than 453 feet. The result would be no more than a foot or two of water at the northwestern toe of the landfill. Four major flood events have occurred since the levee was completed in 1972, including the record level flood of August 1993 when the Missouri River crested at 14.6 feet above flood stage and remained above flood level for about 110 days. The flood control system functioned successfully in each case.

According to information provided on the Earth City Levee District web site, the Levee District has: developed a comprehensive and ongoing maintenance program whereby the entire levee system, relief wells, pump station and other mechanical and electrical systems are inspected at least annually by qualified independent contractors. The Corps inspects the levee and pump station normally on an annual basis. The District's levee and the pump station have qualified for participation in the Corp's rehabilitation assistance program for flood control projects (e.g. Public Law 84-99.) As a result of such participation, the Corps will pay 80 percent of the construction costs incurred in connection with rehabilitation of the levee or pump station resulting from flooding. Costs such as dirt are not covered by the Corps' assistance program.

Subsurface Features

The geology of the landfill area consists of Paleozoic-age sedimentary rocks overlying Pre-Cambrian-age igneous and metamorphic rocks. The Paleozoic bedrock is overlain by unconsolidated alluvial and loess deposits of recent (Holocene) age. Alluvial deposits of varying thickness are present beneath Areas 1 and 2. The landfill debris varies in thickness from 5 to 56 feet in Areas 1 and 2, with an average thickness of approximately 30 feet in Area 2. The underlying alluvium increases in thickness from east to west beneath Area 1. The alluvial thickness beneath the southeastern portion of Area 1 is less than 5 feet (bottom elevation of 420 ft/amsl) while the thickness along the northwestern edge of Area 1 is approximately 80 feet (bottom elevation of 370 ft/amsl). The thickness of the alluvial deposits beneath Area 2 is fairly uniform at approximately 100 feet (bottom elevations of 335 ft/amsl).

During the RI investigations, groundwater was generally encountered in the underlying alluvium near or immediately below the base of the landfill debris. Isolated bodies of perched water were encountered in 2 of the 24 soil borings drilled in Areas 1 and 6 of the 40 borings drilled in Area 2 as part of the RI field investigations. The perched water generally occurs in small isolated units at depths varying from 5 to 30 feet below ground surface. Monthly groundwater levels measured in various landfill wells indicate that only a very small amount of relief (less than a foot) exists in the natural alluvial water table surface. The regional direction of groundwater flow is northerly within the Missouri River alluvial valley, parallel or sub-parallel to the river alignment. However, the leachate collection system for the Former Active Sanitary Landfill creates a localized cone of depression that extends across the eastern half of the Site and includes the water table underlying Area 1.

Vertical hydraulic gradients were calculated using piezometer clusters. The vertical hydraulic gradients for the shallow alluvium to intermediate or deep alluvium and for deep alluvium to shallow bedrock are very small and vary from slightly downward to slightly upward.

Landfill Surface and Subsurface Investigations

Investigations of the landfill soils and perched water included the following:

- Pre-screening of each soil boring location within the landfill for potential large metal obstacles and methane concentrations;
- Drilling of 20 borings in Area 1 and 40 borings in Area 2 (Figure 5-3), including pre-drilling of all planed monitoring wells to be completed through areas underlain by landfill refuse;
- Collection of soil samples from all of the soil borings, generally at five-foot depth intervals and performance of radiological and chemical analyses on selected soil samples from the various soil borings;
- Collection of samples from four background locations potentially representative of daily cover materials and performance of radiological and chemical analyses;
- Downhole radiological logging of all of the newly drilled soil borings and all existing monitoring wells and cased soil borings remaining from prior Site investigations that could be located;
- Collection of selected perched water samples encountered during the soil boring activities; and
- Collection and laboratory testing for selected geotechnical properties of four soil samples obtained from the landfill slope at the northern edge of Area 2 above the former Ford Property.

Based on the data collected, the following observations were made regarding the general Site geologic and hydrogeologic conditions and the nature and configuration of the landfill debris:

- The thickness of the landfill materials varies from 20 to 56 feet in Area 1, and 11 to 45 feet in Area 2;
- Loess (silt, clay, and fine sand) materials were used to cover the landfill debris in Areas 1 and 2;
- Isolated occurrences of perched water were found to be present within the landfill debris and where present, perched water was found to be of very limited extent; and
- Regional (continuous) groundwater generally occurs in the unconsolidated alluvial deposits present below the base of the landfill debris.

Based on the data collected, the ROD made the following observations regarding the occurrences of radiological constituents within the landfill debris. (1) Radionuclides are dispersed in landfill deposits in Areas 1 and 2. Radiological constituents occur in soil materials that are intermixed with and interspersed in the overall matrix of landfilled refuse, debris, fill materials, and unimpacted soil. In some portions of Areas 1 and 2, radiologically impacted materials are present at or near the surface; however, the majority of the radiological occurrences are in the subsurface. (2) The primary radionuclides detected at levels above background concentrations at OU 1 are part of the uranium-238 (U-238) and uranium-235 (U-235) decay series. Isotopes from the thorium-232 (Th-232) decay series are also present above background levels but to a lesser degree. The radionuclides derive from ore processing residues with an elevated ratio of Th-230. The high relative concentration of Th-230 resulted from ore processing designed to separate out uranium and radium, leaving thorium in the residue (by-product). See **Tables 5-2 through 5-6** for a summary of radionuclide occurrences in Areas 1 and 2 and the results of background sampling.

Radionuclides are present in surface soil (0-6 inches in depth) over approximately 50,700 square feet (1.16 acres) of Area 1. Approximately 194,000 square feet (4.45 acres) of Area 1 have radionuclides present in the subsurface at depths ranging up to 7 feet, with localized intervals present to depths of 15 feet.

Radionuclides are present in surface soil covering approximately 468,700 square feet (10.76 acres) of Area 2. An additional 17,200 square feet in the northeastern portion of Area 2 contains soil/sediment eroded from the surface of Area 2. Radionuclide impacted materials are present in the subsurface beneath approximately 817,000 square feet (18.76 acres) of Area 2 at depths of up to approximately 12 feet, with some localized deeper intervals at depths up to 50 feet bgs.

The extent of subsurface occurrences of radionuclides exceeds and encompasses the extent of surficial occurrences of radionuclides in both Areas 1 and 2. Subsurface occurrences of radionuclides are present in soil material that is intermixed with the overall landfill matrix of refuse, debris and fill materials.

Based on the results of sampling performed during the RI, radionuclide occurrences were identified to be present within surface soil (approximately 6- to at most 12-inches deep) beneath that portion of the former Ford property that later became the Buffer Zone and Crossroad Lot 2A2. Radionuclide occurrences were estimated to be present in an area of approximately 196,000 square feet (4.5 acres). Subsequent grading and site development activities by third parties have modified the surface condition and occurrences of radionuclides on these properties.

During preparation of the SFS, the extent of occurrences of thorium-230, radium-226, and uranium-238 in Areas 1 and 2 was rigorously examined to provide a basis for estimating the volume of material that would need to be excavated pursuant to the “complete rad removal” alternatives. The data collected during both the NRC and the RI investigations were used in this evaluation. The specific procedures and data used to identify the volume encompassing the RIM are discussed briefly in Section 2.2.4 and are fully described and presented in Appendix B to the SFS. Based upon these analyses, the SFS identified the horizontal (lateral) extent of radiological occurrences as approximately four acres (approximately 40% of the total area) within Area 1 and as approximately 22 acres (approximately 70% of the total area) within Area 2.

Vertical Extent of RIM Occurrences in Areas 1 and 2

The 1982 Nuclear Regulatory Commission report found radionuclides "to extend from the surface ... to a depth of about 20 feet below surface, in two cases" but generally "ranging from two to fifteen feet thick, located between elevations of 455 feet and 480 feet." With respect to the depth of RIM in Area 1, the RI found that radiologically-impacted materials were generally present at depths ranging between 0 and 17 feet bgs, which corresponds to elevations of approximately 438.5 to 461 feet AMSL [WL-105, 106, 112, 114, 117, 118 with Th, most Ra, and a few U well above cleanup standards down to 5-10'; gamma scans in PVC-25, 26, 28, 36, and 38 elevated down to 17'].

With respect to Area 2, the RI found that, based upon the results of the downhole gamma logging and laboratory analysis of soil samples, radiologically-impacted materials were generally found at depths ranging between 0 to approximately 31 feet bgs. These depths correspond to elevations of approximately 448 to 478.5 feet AMSL. Deeper occurrences of radiologically-impacted materials were identified to be present at three locations in Area 2. In the northern part of Area 2 (area of borings WL-209[24-26', 27.6 pCi/g Th], PVC-4[0-5.5', 2500 pCi/g Ra, 530 pCi/g U], PVC-5[9.5-14.5', elevated gamma scans], PVC-6[0-16', elevated gamma scans] and PVC-7[0-22', elevated gamma scans], see Figure 13) radiologically-impacted materials were identified at depths up to 26 ft corresponding to an elevation of 440 ft. Soil samples obtained from Boring WL-214[4-6', 44.8 pCi/g Th; 24-26', 13.2 pCi/g Th] indicated that radiologically-impacted materials were present at a depth of 26 ft (elevation 442 ft amsl) at this location. In the southern part of Area 2 (borings WL-210[0-16.5', 2285 pCi/g Ra, 18249 pCi/g Th, 400 pCi/g U; 39-49.5', 18.6 pCi/g Th], WL-218[39-41', 7.9 pCi/g Th], WL-233[17-31', 428 pCi/g Th], WL-234[0-21', 3075 pCi/g Ra, 57420 pCi/g Th, 277 pCi/g U] and WL-235[20.5-24.5', elevated gamma scans]), radiologically-impacted materials were identified at depths up to 49.5 ft which corresponds to an elevation of approximately 427 feet AMSL.

These RI findings regarding the vertical extent of the RIM are generally consistent with those reported by the NRC. Therefore, the RI data on vertical extent of the RIM, supplemented by the NRC data, were used to estimate the three-dimensional extent of RIM.

Radiological Occurrences on the Buffer Zone and Crossroad Property

During the RI, radionuclide occurrences in surface soil were identified in the southern portion of what at that time was property owned by Ford Motor Credit (referred to in the RI as the Ford property), located immediately to the north and west of Area 2 (**Figure 14**). Ford sold a portion of the property to Crossroad Properties, LLC (Crossroad), and sold the remaining portion (the Buffer Zone) to Rock Road Industries to provide a buffer between the landfill and the adjacent properties.

Reportedly, after completion of landfilling activities in Area 2 but prior to establishment of a vegetative cover over the landfill berm, erosion of soil from the landfill berm resulted in the transport of radiologically-impacted materials from Area 2 onto the adjacent Buffer Zone and Crossroad properties. The landfill berm and the adjacent properties were subsequently revegetated by natural processes such that no evidence of subsequent erosion or other failures were present. Occurrences of radionuclides were found in surficial (6 to 12 inches or less) soil at the toe and immediately adjacent to the landfill berm as a result of this historic erosion from Area 2. Based on an estimated areal extent of 196,000 square feet and a presumed 6-inch thickness, the volume of radiologically-impacted materials located on the former Ford property was estimated to be 3,600 cubic yards.

In November 1999, third parties scraped the vegetation and surface soil on Crossroad Lot 2A2 and the Buffer Zone to a depth of approximately 2 to 6 inches. These activities were unauthorized and reportedly conducted by AAA Trailer, the current tenant of the Crossroad property. The removed materials were piled in a berm along the southern boundary of the Buffer Zone, adjacent to the northwestern boundary of the West Lake Landfill. A small amount of removed materials was also placed in a small pile on the Crossroad property near the base of the landfill berm along the east side of Lot 2A1.

In February 2000, additional surface soil samples were collected from the disturbed area and submitted for laboratory testing. Only one sample (RC-02) obtained from the Buffer Zone, below and adjacent to the area of the former landfill berm slope failure, contained radionuclides (thorium-230) above levels that would allow for unrestricted use. The remainder of the samples contained either background levels of radionuclides or levels above background but within levels that would allow for unrestricted use. The results of the additional soil sampling indicated that most of the radiologically impacted soil that had previously been present on the Buffer Zone and Lot 2A2 of the Crossroad property had been removed and placed in the stockpiles. Evaluation of the soil sampling results obtained prior to and after the 1999 disturbance indicates that approximately one acre of the Buffer Zone may still contain some radionuclides above reference levels. Inspection of the area in May 2000 indicated that native vegetation had been reestablished over both the disturbed area and the stockpiled materials. The presence of native vegetation over these materials was determined to be sufficient to prevent windblown or rainwater runoff of these materials.

A 2004 inspection of this area indicated that additional soil removal/regrading had been performed on the remaining portion of the Crossroad property and the adjacent Buffer Zone property by, or on the behalf of, AAA Trailer. These activities appear to have resulted in removal of the soil stockpiles created during the previous regrading activity reportedly conducted by AAA Trailer, removal of any remaining soil on Lot 2A2 and the Buffer Zone not scraped up during the 1999 event, and placement of gravel over the entirety of Lot 2A2 and the Buffer Zone. According to AAA Trailer, all of the soil removed during the July 1999 grading work and the May 2003 gravel layer installation was placed in the northeastern corner of the Buffer Zone. Trailers associated with AAA Trailer’s operations were then parked in this area without authorization from the Respondents regarding use of the Buffer Zone. At Respondent’s request, AAA Trailer subsequently removed the trailers from the Buffer Zone, and the Respondents installed a fence between the Buffer Zone and Crossroad property to prevent any future disruption of the Buffer Zone by AAA Trailer or any other party.

Because no sampling has been performed since the most recent (May 2003) grading work conducted by AAA Trailer, the levels and extent of radionuclides, if any that may remain in the soil at the Buffer Zone and Crossroad Property are unknown. Additional soil sampling to determine current conditions with respect to radionuclide occurrences in the Buffer Zone and Crossroad Property soil will be conducted as part of implementation of the selected remedy for this area.

Nonradiological Constituents

Based on the data collected, the following observations were made regarding the occurrences of nonradiological (priority pollutant) constituents within the landfill debris:

• In Area 1, each of the trace metals are present at concentrations above the levels found in the background soils in one or more borings. The levels of trace metals detected in area soil samples are as follows:

Trace Metal	Background Value Milligrams per Kilogram (mg/kg)	Range of Values Detected in Area 1 (mg/kg)
Arsenic	6.35	0.8 – 220
Beryllium	0.59	<0.25 – 3.3
Cadmium	<0.5	<0.5 – 7.9
Chromium	12.83	3.1 – 280
Copper	17.37	1.0 – 230
Lead	38.42	2.8 – 900
Mercury	0.1	< 0.1 – 0.17
Nickel	22.02	4.7 – 3600
Selenium	<0.25	0.25 – 250
Zinc	28.2	16 – 120

• In Area 2, each of the trace metals are present at concentrations above the levels found in the background soils in one or more borings. The levels of trace metals detected in area soil samples are as follows:

Trace Metal	Background Value Milligrams per Kilograms (mg/kg)	Range of Values Detected in Area 1 (mg/kg)
Arsenic	6.35	0.7 - 35
Beryllium	0.59	<0.25 – 2.2
Cadmium	<0.5	<0.5 – 3.4
Chromium	12.83	2.0 - 890
Copper	17.37	1.0 -360
Lead	38.42	<0.25 – 2,200
Mercury	<0.1	<0.1 – 0.27
Nickel	22.02	1.3 - 682
Selenium	<0.25	0.25 – 1.0
Zinc	28.2	<1.0 – 1,100

• In Areas 1 and 2, petroleum hydrocarbons were detected. Gasoline concentrations varied from 240 to 2,600 parts per million (ppm); diesel constituents ranged from 51 to 310 ppm; and motor oil constituents ranged from 19 to 3,100 ppm.

• Volatile organic compounds (VOCs), other than petroleum hydrocarbon constituents, were detected at concentrations generally less than 1 ppm in both Areas 1 and 2.

• Semi-volatile organic compounds (SVOCs), other than petroleum hydrocarbon constituents, were detected in both Areas 1 and 2 at concentrations less than 1 ppm.

• Pesticides were generally detected at concentrations less than 0.01 ppm. Polychlorinated biphenyls (PCBs) were detected in Area 1 at concentrations between 0.033 and 2.6 ppm. PCBs in Area 2 generally varied between 0.017 and 1.6 ppm.

• Based upon the nonradiological data collected, it was concluded that the presence and distribution of these constituents is limited in extent and isolated in nature. Also, there is no correlation between occurrences of radiological and nonradiological constituents.

Perched Water

Based on the data collected, the following observations were made regarding the occurrences of perched water within the landfill debris:

• Distribution of perched water is of limited extent, and the various perched waters are isolated in nature (**Figure 5-6**).

• U-238 decay series constituents were present in each of the perched water samples and the Area 2 seep.

• No U-235 decay series constituents were detected in the perched water.

• All detected priority pollutant metals from the perched water and the Area 2 seep were below their respective maximum contaminant levels (MCLs).

• Ten halogenated and aromatic VOCs were detected in the perched water samples. Three aromatic VOCs were detected in the Area 2 seep.

• Thirteen SVOCs were detected in the perched water samples, while only two SVOCs were detected in the Area 2 seep.

• Eight pesticides were detected in the perched water samples, and PCBs were detected in two of the samples. No pesticides were detected in the Area 2 seep.

• Both the perched water and the Area 2 seep sample exhibited many of the conditions indicative of landfill leachate including: total dissolved solids concentrations ranging from 2,300 to 6,300 ppm; total suspended solids ranging from 1,500 to 6,000 ppm; chloride concentrations ranging from 510 to 1,500 ppm; chemical oxygen demand ranging from 690 to 1,400 ppm; biological oxygen demand ranging from <300 to 460 ppm; and ammonia concentrations ranging from 93 to 220 ppm.

Groundwater Investigation

The scope of the groundwater investigation included:

- Collection of samples from 30 existing wells for gross alpha measurement to evaluate water disposal options;
- Installation of 14 new groundwater monitoring wells;
- Development of 44 new and existing wells (**Figure 5-7**);
- Collection of five sets of groundwater samples from varying sets of wells;
- Analysis of groundwater samples and split samples for a full suite of contaminants; and
- Slug testing of 18 wells to measure hydraulic conductivity.

Based on the data collected, the following observations were made regarding the occurrences of groundwater within the landfill debris:
- Constituents in the U-238, U-235, and Th-232 decay series were detected in both upgradient background wells—S-80 and MW-107;
- Constituents in U-236, U-235, and Th-232 decay series were measured near background levels in wells at the landfill, i.e., generally below 3 picocuries per liter (pCi/l). There were minimal differences between the results obtained from the filtered and unfiltered samples;
- Six of the priority pollutant trace metals—arsenic, chromium, copper, lead, nickel, and zinc—were detected in unfiltered samples from background wells;
- Eight of the priority pollutant trace metals—arsenic, chromium, copper, lead, mercury, nickel, selenium, and zinc—were detected in the unfiltered samples from wells at the landfill. With the exception of the single detection of mercury in well D-14 (0.21 micrograms per liter [µg/l]) and a single detection of selenium in well MW-101 (38 µg/l), all of these trace metals were also detected in the background well samples. For the six trace metals detected in both background and site wells, the levels of the trace metals detected in the unfiltered samples from the wells at the landfill were similar to or less than the levels of the trace metals found in the background wells. The two exceptions were the arsenic results in six of the site wells and the nickel levels in well S-5 (arsenic 13 to 420 µg/l versus background of <0.1 to 20 µg/l and nickel 93 to 110 µg/l versus background of <0.2 to 74 µg/l). Furthermore, with the exception of arsenic and to a lesser extent nickel, the trace metals generally were not detected in the filtered samples;
- Total petroleum hydrocarbons were detected in six wells at concentrations from 0.53 to 3.5 ppm;
- Eleven VOCs including benzene, several chlorobenzene compounds, and acetone (a known laboratory contaminant) were detected in the wells at the landfill. These compounds were not detected in the background wells;
- Four SVOCs (1,4-dichlorobenzene, 4-methyl phenol, and two phthalate compounds, known laboratory contaminants) were detected in wells at the landfill. These compounds were not detected in the background wells;
- Three pesticides were detected in wells at the landfill in the November 1995 sampling episode. They were not detected during the February 1996 episode. No PCBs were detected during either sampling event; and
- The hydraulic conductivity of the shallow material (average of 8×10^{-3} centimeters per second [cm/sec]) is slightly less than average hydraulic conductivity results obtained from the intermediate and deep monitoring wells (4×10^{-2} cm/sec).

Potential Migration Pathways

As shown in **Figure 5-1**, the potential pathways are:
- Airborne transport of radon gas and fugitive dust;

• Rainwater runoff transport of dissolved or suspended contaminants;
• Erosion and transport of contaminated soils; and
• Leaching of contaminants to the underlying alluvial groundwater.

Airborne Transport

Radionuclides in Areas 1 and 2 can be transported to the atmosphere either as a gas in the case of radon or as a fugitive dust in the case of the other radionuclides. Both potential pathways were evaluated based on site-specific data.

Radon gas is discharged as a result of the decay of radium. The radon, like other landfill gases, will migrate upward and be discharged to the air at the surface of Areas 1 and 2. Radon flux measurements were made at 54 locations at Areas 1 and 2. Several locations gave high radon flux measurements; however, the average radon flux readings across Areas 1 and 2 were relatively low. The average radon flux for all 54 measurements is 22 pCi/square meter/second (m2s). The standard established pursuant to the UMTRCA for allowable radon emissions from residual radioactive materials from inactive uranium processing sites [40 CFR 192.02(b)] is 20 pCi/m2s. This standard applies to the average radon emissions across vast tailings piles that are considerably larger than Areas 1 and 2. Given their relatively small size, the net radon contribution to the air from Areas 1 and 2 is considered small. The radon emitted at the surface is subject to the dilution and dispersion processes active in the atmosphere and is unlikely to have an impact beyond the landfill boundaries. However, radon generation does occur and will increase over time due to ingrowth of radium. Therefore, the remedy will address this pathway.

Radon gas from Areas 1 and 2 along with other landfill gases could potentially migrate laterally in the subsurface and be captured by the landfill gas collection system on the south side of Area 1. Factoring in dispersion, the short half-life for radon (3.8 days for radon-222 [Rn-222]), the low overall radon flux from Areas 1 and 2, and the small contribution these areas would make to the gas collection system, this pathway is not expected to present a significant problem. Measurements of radon concentrations near the landfill office and in the Former Active Sanitary Landfill gas collection system did not identify significant levels of radon gas.

Methane gas measurements were performed as part of the RI field investigations. During the RI, methane levels ranging from less than one percent to as much as 45 percent were observed in the various boreholes drilled for the RI. The highest levels of methane were observed in boreholes drilled in Area 1. Lower levels of methane were observed in Area 2; however, methane concentrations greater than five percent methane concentration by volume (the lower explosive limit or LEL for methane) were observed in both Area 1 and Area 2.

Fugitive dust monitoring was conducted at one location in Area 1 and one location in Area 2 in accordance with the approved RI/FS Work Plan. Sampling for fugitive dust monitoring was performed at locations that contained the highest or some of the highest radionuclide concentrations in surface soil samples. Results of the fugitive dust monitoring indicated that although fugitive dust emissions may be a pathway at the landfill, the levels of radionuclides detected in the samples collected during the RI indicated that it is not a significant pathway for radionuclide migration from Areas 1 and 2. Fugitive dust is not considered a significant pathway for radionuclide migration under current conditions, primarily because the surfaces of Areas 1 and 2 for the most part are vegetated, thereby reducing or preventing release of significant amounts of fugitive dust. This pathway could become a concern in the future if the Site's conditions are not monitored and maintained.

Rainwater Runoff and Transport

Radionuclides present in Areas 1 and 2 could potentially be transported to other portions of the landfill or to off-site areas with precipitation runoff from the landfill. Transport with rainwater runoff would include both dissolved phase transport and suspended phase transport within the flowing runoff water. Water samples were obtained during storm events to assess the potential for dissolved or suspended phase transport of site contaminants in precipitation runoff. Low levels of radionuclides were detected in some of the rainwater runoff samples obtained as part of the RI.

As no standards or health-based criteria exist for rainwater runoff, the results of the analyses of these samples were compared to their respective MCLs for drinking water systems; however, as there is no expectation that any potential receptor would actually drink rainwater runoff, the MCLs are not an applicable or relevant and appropriate requirement (ARAR) for rainwater runoff. One of the rainwater runoff samples obtained from an on-site area contained radionuclides at levels slightly above the radium MCL. The analysis indicated that the total of radium-226 (Ra-226) and Ra-228 isotopes in the unfiltered sample was twice the MCL. None of the surface water samples (either dissolved or total fractions) collected from the nearest off-site surface water bodies (surface water retention and detention basins and flood control channel located adjacent to the Site) contained radionuclides at levels above the MCL.

The potential for radionuclide transport in either the dissolved phase or as suspended sediment in rainwater runoff during average storm events is likely limited by the presence of the existing vegetative cover. Therefore, dissolved phase transport in rainwater runoff does not appear to be a significant potential pathway for radionuclide migration under current conditions. Suspended sediment transport in rainwater runoff is a potential pathway for radionuclide migration within and adjacent to Areas 1 and 2; however, based on the results of the off-site sampling, it does not appear to be a significant pathway for off-site migration of radionuclides under current conditions.

Although elevated levels of radionuclides were not found in samples from off-site surface water and sediment, nonetheless rainwater runoff is considered a potential pathway for radionuclide migration from Areas 1 and 2 in the event the condition of these areas were to degrade, e.g., loss of vegetative cover. Rainwater runoff containing dissolved or suspended radionuclides could be transported from Area 1 or the southeastern portion of Area 2 into the drainage ditches at the landfill. Dissolved or suspended radionuclides could be further transported into the perimeter drainage ditch along the northeastern boundary of the landfill (southwestern side of St. Charles Rock Road). From the perimeter drainage ditch, dissolved or suspended radionuclides could potentially enter the water impoundment north of Area 2 depending upon the magnitude and duration of the rainwater runoff. Similarly, rainwater runoff containing dissolved or suspended radionuclides could be transported from the western portions of Area 2, down the landfill slope, and onto the Buffer Zone/Crossroad Property.

Soil Erosion and Sediment Transport

Radionuclides present in Areas 1 and 2 could be transported to other portions of the landfill or to off-site areas through erosional transport of soil and sediment. In order to determine if this has occurred, sediment samples were collected from various surface water diversion ditches, runoff control structures, or erosional channels located on-site and off-site.

Some of the sediment samples collected on-site contained levels of radionuclides above background. One sediment sample collected at the landfill boundary on the southern side of the access road contained Ra-226 at a level of approximately 5 pCi/g above background. The levels of radionuclides detected in off-site sediment samples were generally near or slightly above background.

Soil samples obtained from 5 of the 11 locations on the Buffer Zone/Crossroad Properties contained radionuclides at levels of 5 pCi/g or more above background. All of these samples were from the upper three to six inches of materials. Radionuclides were not detected above background levels in any of the samples obtained from the Buffer Zone/Crossroad Properties at depths of one foot or more.
Based on the results of the sediment sampling, erosion of surface soils in Areas 1 and 2 and subsequent sediment transport to the landfill access road drainage ditch has occurred and continues to occur in response to significant precipitation events. Sediment transport along the landfill access road drainage ditch into the landfill perimeter drainage ditch along St. Charles Rock Road also has occurred. The data do not indicate significant levels of contaminated sediment in the perimeter drainage ditch along St. Charles Rock Road; however, the potential exists for contaminated sediments to migrate from the interior drainage ditches to perimeter drainage ditch. To the extent that sediment transport would occur along the landfill perimeter drainage ditch, any sediment that may be transported along this pathway would accumulate in the surface impoundment north of Area 2. Previous erosional transport—slope failure or mudflow—from the western portion of Area 2 down the landfill berm resulted in transport of radionuclides onto the eastern portion of the Buffer Property and portions of the Crossroad Property located adjacent to the base of the landfill slope on the northwestern boundary of Area 2. The remedy for OU 1 will need to address this migration pathway.

Leaching to Groundwater and Groundwater Transport

Groundwater samples obtained from a network of on-site monitoring wells over a period of years have been analyzed for a wide range of chemicals including radionuclides, trace metals, petroleum hydrocarbon constituents, VOCs, SVOCs, pesticides, and PCBs. Surface water samples have also been analyzed. **Figures 5-8 through 5-12** are maps illustrating groundwater and surface water data collected as part of the Site's OU 1 and OU 2 RI/FS projects. Groundwater and surface water results for chlorobenzene, benzene, dissolved and total lead, dissolved and total arsenic, and dissolved and total radium are illustrated on these figures. These are the only constituents detected in excess of MCLs which are used as a reference level.

The locations of two known sources of groundwater contamination unrelated to the Site are also identified on the figures. PM Resources, located to the east of Area 1 across St. Charles Rock Road, produces a wide variety of animal health care products and chemicals. In addition, a Leaking Underground Storage Tank (LUST) is located at the center of the Site property. As shown by the arrows on these figures, some groundwater flows from these sources toward the Former Active Sanitary Landfill. Some of the contaminants detected as part of the OU 1 and OU 2 investigations may be attributable to these sources. Summaries regarding the nature of these facilities and the potential groundwater releases associated with these can be found in the OU 2 RI/FS documents.

The figures also include the approximate extent of the inward hydraulic gradient that has been established by pumping of about 300 million gallons per year of groundwater/leachate at the Former Active Sanitary Landfill. The sanitary landfill has been pumping about 300 million gallons per year of groundwater/leachate for approximately 15 years and is required by state permit to maintain a significant inward hydraulic gradient throughout post-closure, which will extend for at least another 29 years.

Summary of Constituents Detected in Groundwater – OU1 RI

Chemical	Maximum Detected Concentration (ug/l)	Drinking Water Standards (ug/l)	No. of Wells Chemical Detected Above MCL
Radionuclides			
Radium (total)	8	5	2
Uranium (total)	9	30	0
Trace Metals			
Arsenic	420 / 400	50 / 10	4
Chromium	62 / 22	100	0
Copper	76 / 0	1,000	0
Lead	70 / 8	15	0
Nickel	93/ 110	NA	0
Selenium	38	50	0
Zinc	330 / 77	5,000	0
Volatile Organic Compounds			
Benzene	11	5	3
Toluene	13	1,000	0
Ethyl Benzene	16	700	0
Xylenes	51	10,000	0
Chlorobenzene	170	NA	0
1,2-Dichlorobenzene	8	600	0
1,4-Dichlorobenzene	50	75	0
Cis-1,2-Dichloroethylene	34	70	0
1,1-Dichloroethane	8	NA	0
Acetone	68	NA	0
Semi-volatile Organic Compounds			
1,4-Dichlorobenzene	38	75	1
4-Methylphenol	290	NA	0
Di-n-octylphthalate	13	NA	0
Bis(2-Ethylhexl)phthalate	17	400	0

NA – A drinking water standard (MCL) has not been established for these compounds.

Note: for metals data with slashes, this represents total/filtered results.

• Dissolved Radium: All wells and surface water locations at which dissolved radium concentrations were below the radium MCL of 5 pCi/l are shown in blue on **Figure 12A**. Only one well exhibited a dissolved radium concentration above 5 pCi/l—D-6—with an activity of 5.4 pCi/l.

• Total Radium: All wells and surface water locations at which total radium concentrations were below the radium MCL of 5 pCi/l are shown in blue on **Figure 12B**. Only four wells exhibited a total radium concentration above 5 pCi/l. These exceedances ranged from 5.74 pCi/l to 6.33 pCi/l. The slight exceedances are isolated spatially. Two of the four wells with total radium exceedances are located in areas that are not downgradient of either Radiological Area 1 or Radiological Area 2. One of these locations is on the opposite side of the formerly active landfill and the 250-foot-deep excavated rock quarry in which the solid waste was placed.

The alluvial groundwater underlying and in the immediate vicinity of Areas 1 and 2 and other landfill units have been sampled and analyzed over time. For radionuclides and metals, both filtered and unfiltered samples were analyzed to evaluate dissolved versus colloidal transport. The results generally show sporadic and isolated detections of a small number of contaminants at relatively low concentration levels. These results are not indicative of on-site contaminant plumes, radial migration, or other forms of contiguous groundwater contamination that might be attributable to the landfill units being investigated. Based on frequency of detection and concentration level relative to its MCL, arsenic is by far the most noteworthy COC found in the groundwater. However, even in the case of arsenic, no evidence of radial migration was found, i.e., the detections were not supported by immediately downgradient locations. Total arsenic was detected in many of the samples at concentrations ranging from 0.010 mg/l to 0.420 mg/l. Most results were nondetect or consistent with background. The highest levels of arsenic were detected in shallow well MW-F3 located near the southeast corner of Area 2 (see **Figure 5-11**). None of the wells located near shallow well MW-F3 contained elevated levels of arsenic. The second highest level of arsenic (0.049 mg/l dissolved and 0.094 mg/l total) was detected in deep well D-14 located at the southern portion of Area 1. The results from other wells in this area do not indicate a contiguous occurrence of elevated arsenic levels. It is not clear that the landfill units under investigation are the source of the arsenic in groundwater since many of the significant arsenic detections occurred near roadside drainages at the perimeter of the Site and in many cases, the detections are not clearly downgradient of the landfill units.

The groundwater results show no evidence of significant leaching and migration of radionuclides from Areas 1 and 2. Moreover, perched water from locations in Areas 1 and 2 was sampled and analyzed and elevated concentrations of radionuclides were not detected. This is the case even though the waste materials have been in place without a landfill cover for over 30 years. Significant leaching and migration of radionuclides to perched water or groundwater have not occurred despite landfilled waste materials having been exposed to worst-case leaching conditions from surface water infiltration over a period of decades.

The lack of radionuclide contamination in groundwater at the Site is consistent with the relatively low solubility of most radionuclides in water and their affinity to adsorb onto the soil matrix. This is supported by partitioning calculations presented in the RI which indicate that impacts to groundwater over time may be low. However, radionuclide and nonradionuclide contamination are present in uncovered landfill units and some of these constituents have been detected in groundwater at levels slightly exceeding MCLs. Therefore, caution is warranted regarding the potential for future leaching of contaminants to underlying groundwater and this pathway should be addressed as part of the RA at the Site.

Fate and Transport

The alluvial groundwater underlying the eastern portion of the Site, i.e., groundwater underlying Area 1 and the Former Active Sanitary Landfill, is captured by the inward hydraulic gradient created by the leachate collection system for the Former Active Sanitary Landfill. **Figures 5-8 through 5-12** show the approximate extent of the inward hydraulic gradient. Bordering the Inactive Sanitary Landfill to the west and extending north of the Site is the Earth City Stormwater Retention Pond which acts as a hydraulic barrier to horizontal groundwater flow. Therefore, the potential for off-site groundwater flow under current conditions is generally limited to the western portion of the Site, i.e., groundwater underlying Area 2 and the Inactive Sanitary Landfill. Flow is predominantly horizontal and in the northeasterly direction toward the river. The groundwater contaminants in this zone have the potential to migrate with groundwater flow to off-site locations. This pathway for migration is not considered significant under current conditions because the on-site impact to groundwater from the landfill units is so limited. If groundwater monitoring data show no evidence of a contaminant plume underlying and immediately downgradient of the source material, then it is reasonable to conclude there is no contaminant plume further downgradient at some off-site location that could be attributable to the source material. For this reason, off-site groundwater investigations were not undertaken as part of the RI. However, radionuclide and nonradionuclide contamination is present in the landfill units; the potential for leaching to groundwater and off-site migration is a pathway that should be addressed as part of the remedy for the Site.

Current and Potential Future Site and Resource Uses

Land use in the area surrounding the landfill is almost exclusively commercial and industrial. The property to the north of the landfill across St. Charles Rock Road is moderately developed with commercial, retail, and manufacturing operations. The Earth City Industrial Park is located adjacent to the landfill on the west and southwest, across Old St. Charles Rock Road. Spanish Village, a residential development, is located to the south of the landfill near the intersection of St. Charles Rock Road and Interstate 270, approximately 0.75 mile from the Site. Adjacent to the Spanish Village development is a large industrial park. Mixed commercial, retail, manufacturing, and single-family residential uses are present to the southeast of the landfill.

The Site itself is expected to remain a landfill for the foreseeable future and any on-site commercial uses will need to be compatible with this end use. There are existing land use controls in the form of restrictive covenants executed by the property owner. Development within the Earth City Levee District, which includes all the property to the north, west, and southwest of the Site, is commercial and industrial by design and the Industrial Park is 97 percent developed. Surrounding land use to the south and east is also expected to remain largely commercial/industrial. Zoning in that area is consistent with this observation. Because the surrounding area is already mostly developed, no significant changes in land use are anticipated.

Groundwater Use

The Site is located at the edge of the alluvial valley. Groundwater is present in both the unconsolidated materials (alluvium) and in the bedrock underlying and adjacent to the Site. The major alluvial aquifers in the area are differentiated to include the Quaternary-age alluvium and the basal parts of the alluvium underlying the Missouri River flood plain. The major bedrock aquifers favorable for groundwater development lie at great depth. The St. Peter Sandstone aquifer lies at a depth of approximately 1,450 feet below ground surface. While of regional importance, the major bedrock aquifers are not significant to the study of the Site due to their great depths and intervening shale units. The bedrock units immediately underlying and adjacent to the Site (including the Warsaw, Salem, and St. Louis Formation) are not very favorable for groundwater development, i.e., yield less than 50 gallons per minute to wells. A restrictive covenant prohibiting groundwater use has been placed on the Site.

Investigation during the RI confirmed there is no current groundwater use in the vicinity of the Site. The nearest registered water well is a deep bedrock well located about one mile northeast of the Site. The closest registered alluvial well is 2.5 miles south of the Site. A public water supply intake is located approximately eight miles downstream of the Site. Given the setting and the ready access to municipal drinking water supplies, use of the shallow groundwater at or near the Site is not considered to be a viable pathway for the foreseeable future. Nevertheless, based on potential yields, groundwater in the vicinity of the Site is considered potentially usable. In particular, alluvial groundwater wells completed in the Missouri River flood plain are capable of very high yields.

Human Health Risk Assessment

OU-1 contains both radiological and chemical (non-radiological) constituents of concern (COC). The concentrations and toxicity of these constituents were identified and used in the Baseline Risk Assessment (BRA) to focus the risk assessment on the chemicals and radionuclides most likely to produce risks above the 10^{-6} cancer risk point of departure. Since publication of the BRA, new toxicity information has been made available that required modification of some of the original values used in the BRA's toxicity screening evaluation.

The BRA identified the radionuclides of concern at the West Lake Landfill as those associated with the naturally occurring uranium-238, thorium-232, and uranium-235 decay series. This information is still current. **Table 4-1** reproduces the information in the Table of Radionuclides of Concern presented in the BRA and the indicator radionuclides for series radionuclides or coincident isotopes.

Table 4-1 Radionuclides of Concern in Soil at the West Lake Landfill

Indicator Radionuclides	Radionuclide or Decay Chain
Uranium-238	For Uranium-238 + 2 Daughters and for Uranium-234
Thorium-230	For Thorium-230 and as a source of Radium-226 in growth
Radium-226	For Radium-226 + 8 Daughters (including Radon-222 and Lead-210 and its daughters)
Thorium-232	For Thorium-232 + 10 Daughters
0.05 x [(Uranium-238+Uranium-234)/2] [a]	For Uranium-235 + 1 Daughter
Protactinium-231	For Protactinium-231 + 8 Daughters

a The BRA used this approach to calculate risks from uranium-235 (See Section A.2.2.1 of the BRA).

As in the BRA, radionuclides were not screened against local background values during the COC selection process and all detected radionuclides were carried through the risk assessment process for exposed soil. This conservative approach will slightly overestimate the site-related concentrations of the radiological component of the risk assessment.

The BRA also performed a toxicity screen of the chemicals that were reported at the Site. This toxicity screen has been updated to account for changes that have occurred since publication of the BRA. **Table 4-2** presents the concentrations used in the screening evaluation and the results.

Table 4-2 Summary of Chemical Toxicity Screen for Surface Soil

Analyte	Risk- or HI-Based Industrial Screening Values [a] (mg/kg)	Maximum Soil Concentrations [b] Area 1 (mg/kg)	Area 2 + Boundary (mg/kg)	Selection/Screening of COCs in Soils [c] Area 1 0-1 ft	Area 2 + Boundary 0-1 ft	Screening Result Changed from Baseline?
Inorganic Chemicals						
Arsenic	1.60×10^{00}	220	35	YES	YES	no
Beryllium	2.00×10^{03}	3.3	2.2 [f]	no	no	no
Cadmium	8.00×10^{02}	7.9	6.3 [f]	no	no	no
Chromium (VI)	5.60×10^{00}	31	49 [f]	YES	YES	Added
Copper	4.10×10^{04}	2,300	360	no	no	no
Lead	8.00×10^{02}	320	2,200	no	YES	no
Mercury	4.30×10^{01}	0.17	0.27	no	no	no
Nickel	2.00×10^{04}	3,600	680	no	no	no
Selenium	5.10×10^{03}	250	38	no	no	no
Thallium	1.00×10^{01}	1.2	NA [e]	no	no	no
Uranium	3.10×10^{03}	437.5	875	no	no	Deleted
Zinc	3.10×10^{05}	120	400 [f]	no	no	no
Organic Chemicals						
Acetone	6.30×10^{05}	0.034	0.038	no	no	no
Bis(2-ethylhexyl) phthalate	1.20×10^{02}	7.8	77	no	no	no
Di-n-octylphthalate	1.80×10^{03} [d]	3	12	no	no	no
1,4-Dichlorobenzene	1.20×10^{01}	0.042	0.0065	no	no	no
Fluoranthene	2.20×10^{04}	NA	8.5	no	no	no
Xylenes	2.70×10^{03}	0.037	0.012	no	no	no
Pesticides/PCBs						
Aldrin	1.00×10^{-01}	NA	0.0017	no	no	no
Aroclor-1254	7.40×10^{-01}	1.1	1.6	YES	YES	no
4,4'-DDD	7.20×10^{00}	NA	0.0076	no	no	no
4,4'-DDT	7.00×10^{00}	NA	0.0094	no	no	no

[a] Unless otherwise noted, values are from http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/, June, 2011. When carcinogenic (risk) and non-carcinogenic (hazard) based screening levels were given for a constituent, the lower of the two was selected.
[b] From Table A.2-1 of the BRA (Auxier 2000)
[c] "YES" signifies that the analyte was selected for quantitative risk evaluation, "no" signifies that analyte was not selected for quantitative risk evaluation.
[d] Value from BRA, no updated information identified.
[e] NA = not applicable/ not reported
[f] Measured on the former Ford property (current Buffer Zone and Crossroad Lot 2A2 properties) before surface grading were performed by the adjacent property owner.

Chromium (VI) has been added to the list of chemicals of concern because its maximum reported concentration exceeds the current published screening level of 5.6 mg/kg. The current screening level published for elemental uranium has increased since publication of the BRA. The maximum concentration of elemental uranium is now below the current EPA Regional Screening Level of 3,100 mg/kg and elemental uranium has been removed from noncarcinogenic evaluations (individual isotopes of uranium remain as COCs because they are radiocarcinogens).

Selection and Description of Reasonably Maximally-Exposed Individual

Because postulated exposures associated with this alternative are dependent on close proximity to the RIM, the individuals with the highest potential for exposure would be those receptors spending the most time on or near the cover or the waste (**Table 5-2**). The maintenance of the cover is an essential element of future protective actions for the covered contaminated material.

This assessment assumes there will be workers involved with these maintenance requirements and activities, such as periodically mowing the grass and checking the surface for degradation. Based on the land use restrictions currently in place, additional restrictions described as part of the ROD-Selected Remedy and a review of the types of receptors present in the local community, a member of the grounds keeping crew was selected for this evaluation.

Table 5-2 List of Potential Receptors Identified During Post-Construction ROD-Selected Remedy

Receptors Identified	Scenario Considered? [a]	Exposure Route: Inhalation of Fugitive Dust	Inhalation of Radon	Incidental Soil Ingestion	Dermal Contact	Direct Radiation	Quantitative Evaluation of Scenario?
Grounds Keepers/Maintenance Staff	Yes		•			•	Yes
Transient/Visitors	Yes		{O}			{O}	No
Near-by workers	Yes		{O}				No

a An exposure scenario was considered if it included a source, a means of moving constituents of concern to a location of interest, and a receptor at that location.

• Exposure route selected for detailed analysis

A shaded box indicates that the receptor/exposure route combination was not selected for quantitative analysis.

{O} Not quantified because other receptors identified for this scenario have higher intake rates and longer exposure times.

Risk Assessment Method Used for Radionuclides in Exposed RIM

Radiocarcinogenic risks involving contact with surface soils were calculated using results obtained from the EPA's web-based preliminary remediation goal (PRG) calculator. The PRG calculator provides PRG's radiocarcinogens in exposed soil, one for each exposure route. Using a target risk (TR) of 10^{-6} and the EPA web calculator's default parameters for outdoor worker exposures, it can be determined that the PRG for radium-226 and its short-lived daughters in soil from all exposure routes is 0.0248 pCi/g. Stated another way, every pCi/g of radium-226 in soil can increase the calculated risk of cancer to the hypothetical outdoor receptor by approximately 4.032×10^{-5} (10^{-6} / 0.0248). The EPA web calculator also provides PRGs for individual exposure routes. In this example, the PRG for the external exposure pathway is 0.0249 pCi/g and each additional pCi/g yields an incremental risk of 4.016×10^{-5} (10^{-6} / 0.0249). Comparing these risk numbers, it can be seen that direct radiation from radium and its daughters in exposed soils contribute approximately 99.6% of the risk to the receptor.

In this SFS, risks to specific workers from surface soil will be evaluated using the method presented on the EPA website and illustrated above. However, assessment of carcinogenic risks to individual types of workers identified during the scheduling and manpower evaluation stages of this study may require job-specific changes in parameters such as exposure time and duration. Changes in these parameters and their justifications will be presented as part of the risk evaluation for those jobs. Because the relationship between risk and exposure is linear in nature, the risk results will change linearly with changes in either exposure times or durations. For example, if the calculated risk from 45,000 hours of exposure to soil containing 1 pCi/g of radium-226 is 4.0 x 10^{-5}, then exposure to the same soil for only one hour will be 1/45,000th of that risk or 8.9 x 10^{-10} per pCi/g per hour and a 1,000 hour exposure would yield a calculated risk of 8.9 x 10^{-7}.

Risk Assessment Method Used for Radionuclides in Covered RIM

EPA's PRG calculator calculates risks from radionuclides in surface soils. The PRG calculator does not evaluate risks from buried materials. Two of the alternatives assessed in this SFS involve leaving all RIM securely buried beneath an enhanced engineered cover on-site. Exposure pathways from covered RIM to receptors on the surface of the landfill are limited to exposure to any direct radiation or radon-222 that may pass through the cap. Based on that, another calculation method that incorporated shielding and radon flux attenuation algorithms was used to evaluate risks from covered RIM.

The calculation method selected is incorporated into a computer program called RESRAD 6.5 and its off-site analog RESRAD-OFFSITE 2.5. The RESRAD platform is a widely accepted industry-standard computer code used to evaluate doses and risks from media containing radionuclides via multiple transport and exposure pathways. It was selected for use in this these assessments because it is capable of calculating doses and risks from buried materials for the direct radiation and radon emanation pathways. Other software applications are capable of performing parts of these calculations, but few codes are capable of performing both sets of calculations, and no other program was found to be as widely used by national and international groups and standard setting committees for the evaluation of doses and risks from buried materials.

RESRAD includes slope factors for inhalation, ingestion, and direct external radiation exposures. A few of these slope factors were updated to reflect published changes in EPA's slope factors up to August 26, 2011. While this code can be used to calculate risk from other pathways besides direct radiation and radon, in this assessment the RESRAD code was only used to evaluate risks from buried materials.

Comparison of EPA Web Calculator and RESRAD Results

In order to determine if RESRAD was calculating risks in a manner that was consistent with EPA methodology, risks from direct radiation exposure to surface soil containing radium-226 were calculated using both methods. Risks from radon emanation are not directly addressed in the EPA soil calculator so no direct comparison between the two methodologies could be verified for the radon pathway.

EPA's standard outdoor worker was selected for this comparison. Using a target risk of 10^{-6}, EPA's PRG calculator yields a PRG for the direct radiation exposure route of 0.0249 pCi/g.

A RESRAD calculation of risks from the external pathway was performed using parameter values for that pathway that were consistent with the exposure parameter values for radionuclides in surface soils and outdoor worker exposures found on the EPA website (see **Table 4-6**). Using a concentration for radium-226 and its daughters of 0.0249 pCi/g, the RESRAD calculation yielded a 1.0 x 10^{-6} risk value for the direct radiation exposure route. The two calculation methods are in agreement for direct exposure to external radiation from radium-226 in surface soil.

As stated in previous sections, radiocarcinogenic risks involving exposures to contaminated soils (such as may occur during remediation) were calculated using results obtained from the EPA's web-based PRG calculator. Risks from covered materials are not addressed by the EPA PRG calculator, and the ROD-Selected Remedy and the proposed "Complete Rad Removal" alternatives would leave covered materials on the Site. RESRAD was used to calculate risks only from radiation exposures from covered materials and to radon emanating from covered materials.

Table 4-6 Receptor Parameters Used to Estimate Potential Exposures

Parameter (units)	EPA's Default Outdoor Worker Age 19+
Occupancy	
ED (y)	25[a]
EF (d/y)	225[a]
ET indoors (h/d)	0[b]
ET outdoors (h/d)	8[b]
Inhalation of dusts, volatiles, and radon	
IR (m^3/h)	2.5[a]

[a] EPA Web calculator (http://epa-prgs.ornl.gov/cgi-bin/radionuclides/rprg_search), February 21, 2011.
[b] This assessment assumes an individual works outdoors for 8 hours per day.

Risk Assessment Method Used for Chemical Carcinogens in Exposed RIM

Long-term chemical effects were calculated using the Soil Screening Levels for hypothetical receptors published by EPA. These screening levels can be used to calculate the carcinogenic effects to a hypothetical receptor from 1 mg/kg of a given chemical in soil. For example, the screening level for arsenic acting as a carcinogen is 1.6 mg/kg in surface soil. Therefore, calculated risk to EPA's outdoor worker from surface soil containing 10 mg/kg of arsenic is 6.25 x 10^{-6} (10 mg/kg x 10^{-6}/1.6 mg/kg).

Method Used for Non-carcinogenic Effects of Chemicals in Exposed RIM

The effects associated with exposures to non-carcinogenic chemicals are evaluated differently from the approach used to evaluate carcinogens. Intakes are compared to a reference quantity that represents a safe level of exposure. The ratio of a receptors intake over the reference quantity is termed the Hazard Quotient (HQ) for that chemical in a given exposure scenario. If the HQ exceeds 1, there may be concern of potential health effects. In the case where a receptor receives simultaneous exposures to several chemicals, a Hazard Index (HI) is calculated as the sum of the Hazard Quotients.

Table 4-7 Screening Levels for Carcinogenic Effects to Outdoor Workers Exposed to COCs in Surface Soil (mg/kg)

		Carcinogenic Effects [a]			
Chemical	CAS Number	Ingestion	Dermal	Inhalation	Total
Aroclor-1254	011097-69-1	1.4	1.5	29000	0.74
Arsenic, Inorganic	007440-38-2	1.9	9.6	3900	1.6
Chromium (VI)	018540-29-9	5.7	NA [b]	200	5.6
Lead and Compounds	007439-92-1	NA	NA	NA	NA

[a] http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/, February 21, 2011.
[b] NA = No value listed in EPA's SL database.

Table 4-8 Screening Levels for Non-Carcinogenic Effects to Outdoor Workers Exposed to COCs in Surface Soil (mg/kg)

		Non-Carcinogenic Effects [a]			
Chemical	CAS Number	Ingestion (HQ = 1)	Dermal (HQ = 1)	Inhalation (HQ = 1)	Total (HQ = 1)
Aroclor-1254	011097-69-1	20	22	NA [b]	11
Arsenic, Inorganic	007440-38-2	310	1500	89000	260
Chromium (VI)	018540-29-9	3100	NA	600000	3100
Lead and Compounds	007439-92-1	NA	NA	NA	800

[a] http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/, February 21, 2011.
[b] NA = No value listed in EPA's SL database.

Table 5-5 Long-term Risks and Doses to the Grounds Keeper Calculated for ROD Remedy (Closure in Place)

	Area 1	Area 2
Risk at 1 year	$< 10^{-07}$	2.0×10^{-07}
Risk at 1,000 years	3.1×10^{-07}	1.3×10^{-06}
Dose at 1 year (mrem/y)	1.5×10^{-03}	1.7×10^{-02}
Dose at 1,000 years (mrem/y)	1.3×10^{-02}	1.2×10^{-01}

Exhibit 5-2 Risks to Grounds Keeper in Area 1 – ROD-Selected Remedy Option

Receptor	Risk Year 1	Risk Year 1,000
Grounds Keeper (40 h/y)	$< 10^{-07}$	3.11×10^{-07}

Detailed Risk Data

Excess Cancer Risks from Existent Radionuclides and Pathways in Year 1

Radio-Nuclide	Ground risk	Ground fraction	Radon risk	Radon fraction	All pathways risk	All pathways fraction
Ac-227	6.78×10^{-18}	0.00	0.00×10^{00}	0.00	6.78×10^{-18}	0.00
Pa-231	1.93×10^{-16}	0.00	0.00×10^{00}	0.00	1.93×10^{-16}	0.00
Pb-210	7.04×10^{-19}	0.00	0.00×10^{00}	0.00	7.04×10^{-19}	0.00
Ra-226	8.23×10^{-15}	0.00	3.63×10^{-08}	0.92	3.63×10^{-08}	0.92
Ra-228	2.85×10^{-13}	0.00	0.00×10^{00}	0.00	2.85×10^{-13}	0.00
Th-228	7.08×10^{-14}	0.00	0.00×10^{00}	0.00	7.08×10^{-14}	0.00
Th-230	7.18×10^{-16}	0.00	3.16×10^{-09}	0.08	3.16×10^{-09}	0.08
Th-232	5.86×10^{-13}	0.00	0.00×10^{00}	0.00	5.86×10^{-13}	0.00
U-234	8.99×10^{-22}	0.00	3.94×10^{-15}	0.00	3.94×10^{-15}	0.00
U-235	2.42×10^{-21}	0.00	0.00×10^{00}	0.00	2.42×10^{-21}	0.00
U-238	1.63×10^{-26}	0.00	7.13×10^{-20}	0.00	7.13×10^{-20}	0.00
Total	9.51×10^{-13}	0.00	3.95×10^{-08}	1.00	3.95×10^{-08}	1.00

Excess Cancer Risks from Existent Radionuclides and Pathways in Year 1,000

Radio-Nuclide	Ground risk	Ground fraction	Radon risk	Radon fraction	All pathways risk	All pathways fraction
Ac-227	0.00×10^{00}	0.00	0.00×10^{00}	0.00	0.00×10^{00}	0.00
Pa-231	2.40×10^{-15}	0.00	0.00×10^{00}	0.00	2.40×10^{-15}	0.00
Pb-210	0.00×10^{00}	0.00	0.00×10^{00}	0.00	0.00×10^{00}	0.00
Ra-226	2.44×10^{-14}	0.00	3.42×10^{-08}	0.11	3.42×10^{-08}	0.11
Ra-228	0.00×10^{00}	0.00	0.00×10^{00}	0.00	0.00×10^{00}	0.00
Th-228	0.00×10^{00}	0.00	0.00×10^{00}	0.00	0.00×10^{00}	0.00
Th-230	1.98×10^{-13}	0.00	2.77×10^{-07}	0.89	2.77×10^{-07}	0.89
Th-232	2.55×10^{-12}	0.00	0.00×10^{00}	0.00	2.55×10^{-12}	0.00
U-234	1.54×10^{-17}	0.00	2.16×10^{-11}	0.00	2.16×10^{-11}	0.00
U-235	9.08×10^{-19}	0.00	0.00×10^{00}	0.00	9.08×10^{-19}	0.00
U-238	1.50×10^{-20}	0.00	2.11×10^{-14}	0.00	2.11×10^{-14}	0.00
Total	2.78×10^{-12}	0.00	3.11×10^{-07}	1.00	3.11×10^{-07}	1.00

Exhibit 5-4 Risks to Grounds Keeper in Area 2 – ROD-Selected Remedy Option

Receptor	Risk Year 1	Risk Year 1,000
Grounds Keeper (40 h/y)	$2.03x10^{-07}$	$1.32x10^{-06}$

Detailed Risk Data

Excess Cancer Risks from Existent Radionuclides and Pathways in Year 1

Radio-Nuclide	Ground risk	Ground fraction	Radon risk	Radon fraction	All pathways risk	All pathways fraction
Ac-227	$1.48x10^{-17}$	0.00	$0.00x10^{00}$	0.00	$1.48x10^{-17}$	0.00
Pa-231	$6.61x10^{-16}$	0.00	$0.00x10^{00}$	0.00	$6.61x10^{-16}$	0.00
Pb-210	$1.02x10^{-18}$	0.00	$0.00x10^{00}$	0.00	$1.02x10^{-18}$	0.00
Ra-226	$3.89x10^{-14}$	0.00	$1.91x10^{-07}$	0.94	$1.91x10^{-07}$	0.94
Ra-228	$1.09x10^{-12}$	0.00	$0.00x10^{00}$	0.00	$1.09x10^{-12}$	0.00
Th-228	$2.72x10^{-13}$	0.00	$0.00x10^{00}$	0.00	$2.72x10^{-13}$	0.00
Th-230	$2.53x10^{-15}$	0.00	$1.23x10^{-08}$	0.06	$1.23x10^{-08}$	0.06
Th-232	$2.25x10^{-12}$	0.00	$0.00x10^{00}$	0.00	$2.25x10^{-12}$	0.00
U-234	$2.45x10^{-21}$	0.00	$1.19x10^{-14}$	0.00	$1.19x10^{-14}$	0.00
U-235	$5.27x10^{-21}$	0.00	$0.00x10^{00}$	0.00	$5.27x10^{-21}$	0.00
U-238	$2.66x10^{-26}$	0.00	$1.30x10^{-19}$	0.00	$1.30x10^{-19}$	0.00
Total	$3.66x10^{-12}$	0.00	$2.03x10^{-07}$	1.00	$2.03x10^{-07}$	1.00

Excess Cancer Risks from Existent Radionuclides and Pathways in Year 1,000

Radio-Nuclide	Ground risk	Ground fraction	Radon risk	Radon fraction	All pathways risk	All pathways fraction
Ac-227	$0.00x10^{00}$	0.00	$0.00x10^{00}$	0.00	$0.00x10^{00}$	0.00
Pa-231	$8.22x10^{-15}$	0.00	$0.00x10^{00}$	0.00	$8.22x10^{-15}$	0.00
Pb-210	$0.00x10^{00}$	0.00	$0.00x10^{00}$	0.00	$0.00x10^{00}$	0.00
Ra-226	$1.15x10^{-13}$	0.00	$1.87x10^{-07}$	0.14	$1.87x10^{-07}$	0.14
Ra-228	$0.00x10^{00}$	0.00	$0.00x10^{00}$	0.00	$0.00x10^{00}$	0.00
Th-228	$0.00x10^{00}$	0.00	$0.00x10^{00}$	0.00	$0.00x10^{00}$	0.00
Th-230	$6.96x10^{-13}$	0.00	$1.13x10^{-06}$	0.86	$1.13x10^{-06}$	0.86
Th-232	$9.80x10^{-12}$	0.00	$0.00x10^{00}$	0.00	$9.80x10^{-12}$	0.00
U-234	$4.20x10^{-17}$	0.00	$6.82x10^{-11}$	0.00	$6.82x10^{-11}$	0.00
U-235	$1.98x10^{-18}$	0.00	$0.00x10^{00}$	0.00	$1.98x10^{-18}$	0.00
U-238	$2.45x10^{-20}$	0.00	$3.98x10^{-14}$	0.00	$3.98x10^{-14}$	0.00
Total	$1.06x10^{-11}$	0.00	$1.32x10^{-06}$	1.00	$1.32x10^{-06}$	1.00

Evaluation Criteria	ROD-Selected Remedy	"Complete Rad Removal" with Off-site Disposal	"Complete Rad Removal" With On-site Disposal
Primary Balancing Criteria			
Long-Term Effectiveness and Permanence			
Magnitude of residual risks	Highest long-term risk that would remain upon completion of the remedial action (1.3×10^{-5}) is within EPA's target risk range of 1×10^{-6} to 1×10^{-4}.	Highest long-term risk that would remain upon completion of the remedial action ($<1 \times 10^{-7}$) is less than EPA's target risk range of 1×10^{-6} to 1×10^{-4}.	Highest long-term risk that would remain upon completion of the remedial action (1.5×10^{-5}) is within EPA's target risk range of 1×10^{-6} to 1×10^{-4}.
Short-Term Effectiveness			
Protection of the community during any remedial action	Lowest potential for impacts to the community: Transportation accident incidence:0.61 Carcinogenic risk to residents:3.3×10^{-6} Carbon dioxide emissions: 8,350 tons	Highest potential for impacts to the community: Transportation accident incidence:1.4 Carcinogenic risk to residents:2.1×10^{-5} Carbon dioxide emissions: 35,400 tons	Lower potential for impacts to the community: Transportation accident incidence:0.79 Carcinogenic risk to residents:2.0×10^{-5} Carbon dioxide emissions: 17,900 tons
		Excavation of RIM would create depressions in the waste where precipitation could accumulate increasing the potential for infiltration, leaching and creation of a plume of contamination in groundwater.	Excavation of RIM would create depressions in the waste where precipitation could accumulate increasing the potential for infiltration, leaching and creation of a plume of contamination in groundwater.
	This alternative poses the least potential for increased bird strikes to aviation operations at nearby Lambert-St. Louis International Airport.	This alternative poses potential for increased bird strikes to aviation operations at nearby Lambert-St. Louis International Airport.	This alternative poses greatest potential for increased bird strikes to aviation operations at nearby Lambert-St. Louis International Airport.
Protection of workers during remedial actions	Lowest potential for impacts to workers Industrial accident incidence – 4.7 Carcinogenic risk – 7.2×10^{-5} Worker dose (TEDE) – 50 mrem/yr	Greater potential impacts to workers from increased handling of RIM Industrial accident incidence – 7.6 Carcinogenic risk – 7.6×10^{-4} Worker dose (TEDE) – 260 mrem/yr	Greater potential impacts to workers due to increased handling of RIM Industrial accident incidence – 9.0 Carcinogenic risk – 7.4×10^{-4} Worker dose (TEDE) – 260 mrem/yr

Ecological Risk Assessment

The BRA for OU 1 included a screening-level ecological risk assessment consistent with EPA guidance. The purpose of the screening-level risk assessment is to determine if a potential for adverse impacts to ecological receptors from exposure to COCs exists at the Site and to determine which chemicals and exposure pathways are driving the potential risk or present the greatest potential risk. There is a significant amount of uncertainty associated with the actual potential for ecological impacts. A screening-level risk assessment deals with the uncertainty by using highly conservative assumptions when estimating potential risks. In this way, sites for which there is no potential for ecological risk may be screened out from further assessment. On the other hand, if the screening-level risk assessment indicates that potential risks exist, this does not necessarily mean that site-related chemicals are impacting ecological receptors.

The results of the screening-level risk assessment for OU 1 indicate that ecological receptors are potentially at risk from exposure to COCs, especially metals, in both Areas 1 and 2. The metals could adversely affect plants and soil invertebrates. Small burrowing animals may be at risk from exposure to radioactive materials in Area 2. It should be noted that both Areas 1 and 2 currently support vegetative and animal communities. There is no observable impact to the health of the plant communities. Uptake of metals and bioaccumulation in the food chain may affect higher organisms. Based on the models used in this risk assessment, risk to ecological receptors may result from the bioaccumulation of metals in plants and earthworms. Exposure via food sources was the predominant exposure pathway for primary consumers. Exposure of predators was directly related to the concentrations of chemicals in plants and/or earthworms and the proportion of these contaminated food sources in the diet.

Selenium was the only COC for the red-tailed hawk. Exposure to all other contaminants present at the Site is not likely to have an adverse affect on this animal. Exposure to selenium was primarily the result of bioaccumulation in the food. Food accounts for over 99 percent of the exposure and the relative contributions from the various prey animals are proportional to the amount of vegetation in the prey animal's diet. The uptake of selenium in plants is likely over estimated because the bioaccumulation factor used was more representative of selenium bioaccumulating plants which are not found at the Site. The use of maximum bioaccumulation factors for prey animals is likely to have resulted in even greater over estimation of predator exposure.

Similarly, selenium was the predominant risk driver for the white-footed mouse, cottontail rabbit, and the American robin. It was one of the predominant risk drivers for the red fox and the American woodcock. The primary exposure pathway was bioaccumulation of the contaminant within the food chain, especially uptake by plants. As was previously described, the uptake of selenium in plants and bioaccumulation in prey animals is likely over estimated.

It should be noted that the OU 1 areas are located within a landfill operation. Some of the ecosystems present in these areas are the result of access controls and the fact that field succession has been allowed to occur. Remediation of OU 1 may significantly alter or destroy the habitats that currently exist, forcing wildlife present to migrate to other areas. The increasing commercial/industrial development of the land surrounding the Site has removed significant amounts of wildlife habitat. This process may result in a reduction in the number of larger species in the area and the reduction of the overall ability of the area to support some types of wildlife.

Remedial Action Objectives and Preliminary Remediation Goals

RAOs for Areas 1 and 2 of OU 1

- Prevent direct contact with landfill contents including exposure to external radiation
- Minimize infiltration and any resulting contaminant leaching to groundwater
- Control surface water runoff and erosion
- Control and treat landfill gas emissions including radon

RAOs for Buffer Zone/Crossroad Property portion of OU1

- Prevent direct contact with contaminated surface soils or ensure contaminant levels are low enough to allow for unlimited use and unrestricted exposure.

There are no cleanup standards set for soil or groundwater at the site. The radiologically impacted material is confined to the MSW within the landfill. No plume of contaminated groundwater is present at the site. Because the RI/FS did not identify a groundwater contamination problem, no groundwater RAO is required. Groundwater monitoring, however, is included with the cap-in-place remedy because it is a standard component of post-closure care at municipal solid waste landfills, regardless of whether a groundwater contaminant plume has been identified.

Description of Alternatives

Remedial alternatives and technologies were evaluated in two phases: the 2006 FS and the 2011 Supplemental Feasibility Study (SFS). The 2011 SFS re-evaluated *in greater detail* two of the remedies from the 2006 FS (cap-in-place and excavation with off-site disposal), and added a detailed evaluation excavation with on-site disposal in a new engineered landfill cell. The three remedies evaluated in the 2011 SFS, which is the basis for the proposed ROD amendment, are summarized here. For other remedies and technologies not evaluated in the SFS, see the 2006 FS.

Because of the presence of radionuclides in the waste material in Areas 1 and 2 of OU-1 at the West Lake Landfill, EPA's Technology Reference Guide for Radioactively Contaminated Media was used as a reference for technologies that can effectively treat radioactively contaminated sites. EPA's Reference Guide includes 13 treatment technologies that can potentially be applied to radiologically-contaminated solid media. To address the two "complete rad removal" alternatives in this SFS, some technologies that were screened-out or not retained in the FS were revisited, and additional technologies from the Reference Guide were also evaluated relative to the development of the two "complete rad removal" alternatives. The treatment evaluation in the SFS concluded that none of the 13 treatment technologies were able to deal with the extremely heterogeneous mixture of radiologically-contaminated soil and MSW. Thus, none of the remedies evaluated in the SFS meet the preference for treatment.

Institutional controls are part of each of the three alternatives and will be implemented through restrictive covenants that will be maintained in perpetuity.

ROD-selected Remedy Components

- Installation of a landfill cover meeting the Missouri closure and post-closure care requirements for sanitary landfills, including enhancements consistent with the standards for uranium mill tailing sites, (i.e., armoring layer and radon barrier);
- Consolidation of radiologically contaminated surface soil from the Buffer Zone/Crossroad Property to the containment area;
- Application of groundwater monitoring and protection standards consistent with requirements for uranium mill tailing sites and sanitary landfills;
- Control of surface water runoff;
- Gas monitoring and control including radon and decomposition gas as necessary;
- Institutional controls to prevent land and resource uses that are inconsistent with a closed sanitary landfill site containing long-lived radionuclides; and
- Long-term surveillance and maintenance of the remedy.

"Complete Rad Removal" with On-site Disposal Alternative Components

- Excavating stockpiled soil from the current OU-2 on-site soil borrow and stockpile area and relocating the soil material to the area of the previously closed leachate lagoon;
- Construction of the liner system for the on-site engineered disposal cell at the site of the current OU-2 on-site soil borrow and stockpile area;
- Excavation and stockpiling of overburden in OU-1 Areas 1 and 2 in order to access the RIM;

- Excavation of RIM from OU-1 Areas 1 and 2 that contains radionuclides above levels that would allow for unrestricted use relative to the presence of radionuclides;
- Survey and identification of the presence and extent or radiologically-impacted soil on the Buffer Zone and Crossroad property;
- Excavation of any soil from the Buffer Zone and/or Crossroad property that contains radionuclides at levels greater than those that would allow for unrestricted use;
- Loading and transport of the RIM and impacted soil to the on-site engineered disposal cell and placement and compaction of the RIM in the cell;
- Closure of the on-site cell with a final cover configuration consistent with both the MDNR solid waste regulations and UMTRCA requirements;
- Regrading of the remaining solid waste materials within Areas 1 and 2 to meet the minimum (5%) and maximum (25%) slope criteria;
- Installation of a landfill cover meeting the Missouri closure and post-closure care requirements for sanitary landfills over Areas 1 and 2;
- Design, installation and maintenance of surface water runoff controls;
- Groundwater monitoring consistent with the requirements for sanitary landfills;
- Landfill gas monitoring and control, as necessary;
- Leachate monitoring and control for the on-site cell, as necessary;
- Institutional controls for the on-site cell to prevent land and resource uses that are inconsistent with a closed sanitary landfill site containing long-lived radionuclides and institutional controls for Areas 1 and 2 relative to the presence of solid wastes in these areas; and
- Long-term surveillance and maintenance of the landfill cover in Areas 1 and 2 and the cover of the on-site engineered cell.

"Complete Rad Removal" with Off-site Disposal Alternative Components

- Excavation and stockpiling of overburden in OU-1 Areas 1 and 2 in order to access the RIM;
- Excavation of RIM from the OU-1 Areas 1 and 2 that contains radionuclides above levels that would allow for unrestricted use relative to the presence of radionuclides;
- Survey and identification of the presence and extent or radiologically-impacted soil on the Buffer Zone and Crossroad property;
- Excavation of any soil from the Buffer Zone and/or Crossroad property that contains radionuclides at levels greater than those that would allow for unrestricted use;
- Loading, transport, and disposal of the RIM and impacted soil at an off-site disposal facility;
- Regrading of the remaining solid waste materials within Areas 1 and 2 to meet the minimum (5%) and maximum (25%) slope criteria;
- Installation of a landfill cover meeting the Missouri closure and post-closure care requirements for sanitary landfills over Areas 1 and 2;
- Design, installation and maintenance of surface water runoff controls;
- Groundwater monitoring consistent with the requirements for sanitary landfills;
- Landfill gas monitoring and control, as necessary;
- Institutional controls to prevent land and resource uses that are inconsistent with a closed sanitary landfill site containing; and
- Long-term surveillance and maintenance of the landfill cover in Areas 1 and 2.

Evaluation Criteria	ROD-Selected Remedy	"Complete Rad Removal" with Off-site Disposal	"Complete Rad Removal" With On-site Disposal
Primary Balancing Criteria (cont.)			
Implementability (cont.)			
Availability of Services and Materials (cont.)	Technologies included as part of this alternative are generally available and sufficiently demonstrated. No prospective technologies are anticipated as part of this alternative.	Technologies included as part of this alternative are generally available and sufficiently demonstrated. No prospective technologies are anticipated as part of this alternative. Use of physical separation techniques could, if effective, reduce the overall cost of this alternative; however, the potential effectiveness, implementability, risks and cost of such techniques cannot be determined from available information. An on-site pilot-scale test would be necessary to make such determinations.	Technologies included as part of this alternative are generally available and sufficiently demonstrated. No prospective technologies are anticipated as part of this alternative.
Cost			
Capital cost	$41,400,000	$259,000,000 - $415,000,000	$117,000,000
O&M costs	$42,000 - $414,000	$40,000 - $412,000	$52,000 - $604,000
Total costs (30 years):			
No fiscal constraint			
Present worth	$43,000,000	$250,000,000 - $401,000,000	$112,000,000
Total (non-discounted)	$45,000,000	$262,000,000 - $419,000,000	$121,000,000
Fiscally constrained ($10M/yr):			
Present worth	$46,000,000	$211,000,000 – *Not Estimated*	$121,000,000
Total (non-discounted)	$49,000,000	$286,000,000 – *Not Estimated*	$141,000,000

Comparative Analysis of Alternatives

See table on next pages.

Evaluation Criteria	ROD-Selected Remedy	"Complete Rad Removal" with Off-site Disposal	"Complete Rad Removal" With On-site Disposal
Threshold Criteria			
Overall Protection of Human Health and the Environment	All of the alternatives would be protective of human health and the environment. All alternatives eliminate or reduce potential exposures to (1) external gamma radiation, (2) radon emissions, (3) inhalation or ingestion of contaminated soil or wastes, (4) dermal contact with contaminated soil or waste, and (5) dispersal of contaminants in fugitive dust. All of the alternatives would reduce potential infiltration of precipitation into the waste and thereby reduce the potential for leaching to groundwater. All alternatives include institutional controls to ensure that only land and resource uses that are consistent with the remedy and protective of human health and the environment are allowed in the future.		
Compliance with ARARs			
Compliance with Chemical-Specific ARARs	All of the alternatives would comply with chemical-specific ARARs including (1) uranium mill tailing standards for radon emissions, maximum concentrations for groundwater protection, and cleanup of contaminated land (Buffer Zone and Crossroad Property), (2) radon NESHAP, (3) Missouri radiation protection standards, and (4) Missouri maximum contaminant levels (MCLs).		
Compliance with Location-Specific ARARs	Would meet location-specific ARARs including solid waste regulation standards relative to 100-year floodplain and proximity to airport runways.	Would meet location-specific ARARs including solid waste regulation standards relative to 100-year floodplain and proximity to airport runways.	Would meet location-specific ARARs including solid waste regulation site selection standards relative to airport runways, 100-year floodplain, wetlands, seismic zones, and unstable ground. May not meet all FAA requirements (TBCs) relative to airport runways because location of on-site cell is within 8,000 feet of end of westernmost runway at Lambert-St. Louis International Airport.
Compliance with Action-Specific ARARs	Would meet action-specific ARARs including Missouri solid waste regulations closure and post-closure standards and uranium mill tailing standards for longevity of disposal facilities.	Would meet action-specific ARARs including Missouri solid waste regulation closure and post-closure standards, DOT and NRC standards for shipment of radioactive wastes, and disposal facility waste acceptance criteria.	Would meet action-specific ARARs including Missouri solid waste regulations for design, operation, closure and post-closure of a solid waste landfill and uranium mill tailing standards for longevity of disposal facilities. Would NOT comply with Missouri solid waste prohibition on disposal of radioactive contaminated material in solid waste disposal cell.

Evaluation Criteria	ROD-Selected Remedy	"Complete Rad Removal" with Off-site Disposal	"Complete Rad Removal" With On-site Disposal
Primary Balancing Criteria			
Long-Term Effectiveness and Permanence			
Magnitude of residual risks	Highest long-term risk that would remain upon completion of the remedial action (1.3×10^{-6}) is within EPA's target risk range of 1×10^{-6} to 1×10^{-4}.	Highest long-term risk that would remain upon completion of the remedial action ($<1 \times 10^{-7}$) is less than EPA's target risk range of 1×10^{-6} to 1×10^{-4}.	Highest long-term risk that would remain upon completion of the remedial action (1.5×10^{-6}) is within EPA's target risk range of 1×10^{-6} to 1×10^{-4}.
Adequacy and reliability of controls	Engineering measures including construction, inspection and maintenance of a final cover would be the primary methods used to control waste materials that remain on site. These types of measures have been demonstrated to be effective at numerous solid waste and NCP sites. Conceptual design of the new landfill covers is based on established designs for solid waste disposal sites, augmented to limit increased gamma radiation and radon emissions expected to occur over a 1,000 period from decay of thorium. Includes rip-rap armor along toe of Area 2 to provide protection against flooding in the unlikely event of failure of the Earth City Flood Control levees or stormwater management systems. Engineering measures would be augmented and supported by existing and additional institutional controls which also have been used at numerous solid waste and NCP sites.	Includes excavation and removal of radiologically-impacted materials above levels which would allow for unrestricted use relative to radiological contamination to an off-site disposal site, and thus is potentially more reliable than the other alternatives. Engineering measures including construction, inspection and maintenance of a final cover would be the primary methods used to control waste materials that remain on site. These types of measures have been demonstrated to be effective at numerous solid waste and NCP sites. Engineering measures would be augmented and supported by existing and additional institutional controls which also have been used at numerous solid waste and NCP sites.	Engineering measures including construction and closure of a new engineered waste disposal cell and construction, inspection and maintenance of a final cover would be the primary methods used to control waste materials that remain on site. These types of measures have been demonstrated to be effective at numerous solid waste and NCP sites. Engineering measures would be augmented and supported by existing and additional institutional controls which also have been used at numerous solid waste and NCP sites. Conceptual design of the new landfill cell is based on established designs for solid waste disposal sites, augmented to limit increased gamma radiation and radon emissions expected to occur over a 1,000 period from decay of thorium.

Evaluation Criteria	ROD-Selected Remedy	"Complete Rad Removal" with Off-site Disposal	"Complete Rad Removal" With On-site Disposal
Primary Balancing Criteria (cont.)			
Reduction of Toxicity, Mobility or Volume through Treatment	None of the alternatives include treatment technologies that would reduce the toxicity, mobility or volume of waste material through treatment as a primary component. Treatment technologies are generally not applicable to the site wastes due to the nature and overall large volume of wastes, combined with the fact that radionuclides are naturally occurring elements that cannot be neutralized or destroyed by treatment. All of the alternatives include off-site treatment and disposal of hazardous wastes in accordance with the RCRA regulations if any such wastes are encountered during implementation of the remedy.		
Short-Term Effectiveness			
Protection of the community during any remedial action	Lowest potential for impacts to the community: Transportation accident incidence:0.61 Carcinogenic risk to residents:3.3×10^{-6} Carbon dioxide emissions: 8,350 tons	Highest potential for impacts to the community: Transportation accident incidence:1.4 Carcinogenic risk to residents:2.1×10^{-5} Carbon dioxide emissions: 35,400 tons	Lower potential for impacts to the community: Transportation accident incidence:0.79 Carcinogenic risk to residents:2.0×10^{-5} Carbon dioxide emissions: 17,900 tons
		Excavation of RIM would create depressions in the waste where precipitation could accumulate increasing the potential for infiltration, leaching and creation of a plume of contamination in groundwater.	Excavation of RIM would create depressions in the waste where precipitation could accumulate increasing the potential for infiltration, leaching and creation of a plume of contamination in groundwater.
	This alternative poses the least potential for increased bird strikes to aviation operations at nearby Lambert-St. Louis International Airport.	This alternative poses potential for increased bird strikes to aviation operations at nearby Lambert-St. Louis International Airport.	This alternative poses greatest potential for increased bird strikes to aviation operations at nearby Lambert-St. Louis International Airport.
Protection of workers during remedial actions	Lowest potential for impacts to workers Industrial accident incidence – 4.7 Carcinogenic risk – 7.2×10^{-5} Worker dose (TEDE) – 50 mrem/yr	Greater potential impacts to workers from increased handling of RIM Industrial accident incidence – 7.6 Carcinogenic risk – 7.6×10^{-4} Worker dose (TEDE) – 260 mrem/yr	Greater potential impacts to workers due to increased handling of RIM Industrial accident incidence – 9.0 Carcinogenic risk – 7.4×10^{-4} Worker dose (TEDE) – 260 mrem/yr
Environmental impacts of any remedial action	No measurable long-term impacts to plants or animals are expected to occur from any of the alternatives. No wetlands are present on-site and no endangered species were identified in the site area. Regrading and/or excavating Area 2 would disturb the landfill surface and destroy the habitat that currently exists in this area, but this would be replaced by vegetative cover equivalent to an early stage field succession.		

Evaluation Criteria	ROD-Selected Remedy	"Complete Rad Removal" with Off-site Disposal	"Complete Rad Removal" With On-site Disposal
Primary Balancing Criteria (cont.)			
Short-Term Effectiveness (cont.)			
Time until RAOs are achieved	Implementation of institutional controls is included as part of all of the alternatives and would take approximately 1 year to implement. Potential threats would be addressed upon implementation of institutional controls. No potential threats would remain after implementation of any of the alternatives. Note: NTP for entries below is notice to proceed with RD.		
	RAOs would be achieved upon completion of construction 3 yrs after NTP w/ no fiscal constraint 5 yrs after NTP if fiscal constraint	RAOs would be achieved upon completion of construction 4 yrs after NTP w/ no fiscal constraint 29 yrs after NTP if fiscal constraint	RAOs would be achieved upon completion of construction 6 yrs after NTP w/ no fiscal constraint 13 yrs after NTP if fiscal constraint
Implementability			
Technical Feasibility	All of the alternatives are constructible.		
		There is uncertainty regarding the actual volumes of RIM that would need to be removed and the volume of daily cover that would be added resulting in uncertainty the actual disposal volume. The ability to remove deeper occurrences of RIM from Area 2 is a technical difficulty with this alternative and might result in schedule delays. The ability to locate a rail spur near the site or to construct a rail spur to and on the site is a technical difficulty that could limit the performance and schedule of this alternative. Reductions in the number of rail cars or the frequency of exchange of full and empty rail cars could impact the schedule for this alternative.	There is uncertainty regarding the actual volumes of RIM that would need to be removed and the volume of daily cover that would be added resulting in uncertainty the actual disposal volume. The ability to remove deeper occurrences of RIM from Area 2 is a technical difficulty with this alternative that might result in schedule delays. Construction and operation of a new engineered disposal cell is a common technology that has been demonstrated to be reliable. Only one possible location for a new disposal cell could be identified due to the Missouri river geomorphic floodplain. Subsurface conditions at this location are unknown and could affect technical feasibility and/or capacity of a new disposal cell.

Evaluation Criteria	ROD-Selected Remedy	"Complete Rad Removal" with Off-site Disposal	"Complete Rad Removal" With On-site Disposal
Primary Balancing Criteria (cont.)			
Implementability (cont.)			
Technical Feasibility (cont.)	Landfill cover systems have been used extensively and with proper inspection and maintenance have been demonstrated to be reliable. Stormwater controls and environmental monitoring are commonly used techniques that have been demonstrated to be reliable.	Excavation and offsite disposal is a common and reliable technology. Landfill cover systems have been used extensively and with proper inspection and maintenance have been demonstrated to be reliable. Stormwater controls and environmental monitoring are commonly used and demonstrated reliable techniques. Per the FAA, the reliability of most bird mitigation technologies are questionable.	Landfill cover systems have been used extensively and with proper inspection and maintenance have been demonstrated to be reliable. Stormwater controls and environmental monitoring are commonly used and demonstrated reliable techniques. Per the FAA, the reliability of most bird mitigation technologies are questionable.
	The only future actions anticipated to be required for all of the alternatives are ongoing inspection, monitoring, maintenance and, if needed, repair of the final landfill covers which should be easily implemented. All of the alternatives include a provision for a contingent landfill gas control system in the event the monitoring of subsurface occurrences of landfill gas or radon indicates a need for such a system.		
	Performance of all the alternatives can be monitored and potential risk of exposure in the event of failure of any of the alternatives would be low.		
Administrative Feasibility	Requires coordination and permitting with MSD for disposal of leachate and stormwater during construction. Requires access to Crossroad Property for investigation/removal of soil. Requires coordination with Earth City Flood Control district for design and operation of long-term stormwater management systems. May require preparation and approval of a traffic control plan for St. Charles Rock Road.	Implementation would require approval and verification of current acceptability for off-site disposal from EPA. Use of the Clean Harbors facility for disposal would require approval by the Rocky Mountain Low Level Radioactive Waste Compact. Construction of a rail spur would require leasing/acquisition of property located on the east side of St. Charles Rock Rd. and permission to construct a rail crossing over St. Charles Rock Rd.	Requires approval of City of St. Louis (unlikely based on prior discussions) to temporarily remove its Negative Easement and Restrictive Covenant against additional landfilling at the site and resultant impacts to airport safety. Requires coordination with and possible approval by the FAA for construction and operation a new disposal cell within 10,000 ft of the end of the westernmost runway at Lambert-St. Louis International Airport.

Evaluation Criteria	ROD-Selected Remedy	"Complete Rad Removal" with Off-site Disposal	"Complete Rad Removal" With On-site Disposal
Primary Balancing Criteria (cont.)			
Implementability (cont.)			
Administrative Feasibility (cont.)		Requires coordination and permitting with MSD for disposal of leachate and stormwater during construction. Requires access to Crossroad Property for investigation/removal of soil. Requires coordination with Earth City Flood Control district for design and operation of long-term stormwater management systems. May require development and approval of a traffic control plan for St. Charles Rock Road.	Requires MDNR approval to construct haul roads over previously closed portions of the permitted landfill. Requires coordination and permitting with MSD for disposal of leachate and stormwater during construction. Requires access to Crossroad Property for investigation/removal of soil. Requires coordination with Earth City Flood Control district for design and operation of long-term stormwater management systems. May require preparation and approval of a traffic control plan for St. Charles Rock Road.
Availability of Services and Materials	Preliminary discussions with MSD indicate that it is willing and has sufficient capacity to accept leachate or stormwater that may be generated during construction. Alternatively, off-site disposal facilities are available to accept these materials if necessary	Only 2 or possibly 3 off-site disposal facilities are available that could accept the types of wastes in Areas 1 and 2. Preliminary discussions with MSD indicate that it is willing and has sufficient capacity to accept leachate or stormwater that may be generated during construction. Alternatively, off-site disposal facilities are available to accept these materials if necessary.	Preliminary discussions with MSD indicate that it is willing and has sufficient capacity to accept leachate or stormwater that may be generated during construction and leachate that may accumulate in the new on-site disposal cell. Alternatively, off-site disposal facilities are available to accept these materials if necessary.
	Adequate equipment, materials, and specialists necessary to implement this alternative are anticipated to be available.		

Evaluation Criteria	ROD-Selected Remedy	"Complete Rad Removal" with Off-site Disposal	"Complete Rad Removal" With On-site Disposal
Primary Balancing Criteria (cont.)			
Implementability (cont.)			
Availability of Services and Materials (cont.)	Technologies included as part of this alternative are generally available and sufficiently demonstrated. No prospective technologies are anticipated as part of this alternative.	Technologies included as part of this alternative are generally available and sufficiently demonstrated. No prospective technologies are anticipated as part of this alternative. Use of physical separation techniques could, if effective, reduce the overall cost of this alternative; however, the potential effectiveness, implementability, risks and cost of such techniques cannot be determined from available information. An on-site pilot-scale test would be necessary to make such determinations.	Technologies included as part of this alternative are generally available and sufficiently demonstrated. No prospective technologies are anticipated as part of this alternative.
Cost			
Capital cost	$41,400,000	$259,000,000 - $415,000,000	$117,000,000
O&M costs	$42,000 - $414,000	$40,000 - $412,000	$52,000 - $604,000
Total costs (30 years):			
No fiscal constraint			
Present worth	$43,000,000	$250,000,000 - $401,000,000	$112,000,000
Total (non-discounted)	$45,000,000	$262,000,000 - $419,000,000	$121,000,000
Fiscally constrained ($10M/yr):			
Present worth	$46,000,000	$211,000,000 – *Not Estimated*	$121,000,000
Total (non-discounted)	$49,000,000	$286,000,000 – *Not Estimated*	$141,000,000

The cost estimates summarized above and provided elsewhere in this SFS are feasibility level cost estimates; that is, they were developed to a level of accuracy such that the actual costs incurred to implement the alternatives should fall within a range bounded by 50% above and 30% below these estimates.

Principal Threat Wastes

The 2008 ROD stated: "The hazardous substances at OU1 are dispersed in a heterogeneous mix of municipal solid waste. No principal threat wastes have been identified." This determination was based on the 1991 Guidance (OSWER 9380.3-06FS) which stated: "Principal threat wastes" are those source materials considered to be highly toxic or highly mobile that generally cannot be reliably contained or would present a significant risk to human health or the environment should exposure occur.

EPA reached the conclusion that no principal threat wastes were present in the 2008 ROD based on its finding that the RIM, though highly toxic, was not highly mobile, since no plume could be found emanating from the un-capped landfill cells more than 35 years after the RIM was placed.

When scoping the SFS work plan in 2010, HQ re-examined the 2008 ROD determination regarding principal threat waste and concluded that the soil-and-MSW mixture in OU1 is in fact principal threat waste, as there were such high levels of radioactive wastes, that should exposure occur, they would present a significant risk to human health or the environment.

Ra-226 was found in soil borings at levels as high as 22,000 pCi ((NRC Report) and thorium-230 was found in soil borings at levels as high as 57,300 pCi/g (RI Report). Following EPA's direction, the SFS conservatively assumed that principal threat waste may be present within OU-1 and evaluated potential treatment technologies as if such waste were present. This took into account both the presence of the RIM and the expected further ingrowth of radionuclides in the RIM due to radioactive decay and disequilibrium. Note that the Principal Threat Waste guidance (OSWER 9380.3-7FS) acknowledges that "…there may be situations where wastes identified as constituting a principal threat may be contained rather than treated due to difficulties in treating the wastes." As discussed earlier, none of the treatment technologies evaluated were proven feasible to treat the soil-and-MSW mixture.

Preferred Alternative

The preferred alternative is the ROD-selected remedy of capping in place, as described above. Minor modifications to the remedy as stated in the 2008 ROD were proposed in the SFS and in the May 2009 OSRTI memorandum to Region 7, including rip-rap armoring of the toe of the Area 2 cap as additional defense against flood damage, on- and off-site air and groundwater monitoring, and a cap design meeting the 1,000 year design life target specified in UMTRCA. In addition, the SFS provided refined cap thickness calculations, a revised plan for grading the existing landfill cells to accept the caps, and bird mitigation measures during construction.

None of the three alternatives evaluated in the SFS meet the preference for treatment, so this is not a differentiating factor between the alternatives. All three of the remedies evaluated in the SFS pose very similar residual human health risks in the long term, but the preferred remedy is by far the most cost-effective of the three. The preferred alternative also poses short-term human health risks to residents and workers during construction that are an order of magnitude less than those posed by either of the excavation alternatives. Risks due to transportation accidents (shipping of waste, cap materials, etc) are least with the preferred alternative. Finally, the preferred alternative offers the least risk to operations at the adjacent Lambert - St. Louis Airport, and is the most compliant with the Airport's restrictive covenant on the Site preventing further landfill activities.

Applicable or Relevant and Appropriate Requirements

A complete list of ARARs is contained in Tables 5, 6, and 7 of the SFS. The following is a subset of that extensive list.

The Uniform Mine Tailings Radiation Control Act (UMTRCA, 40 CFR 192) is an ARAR for the Buffer Zone / Crossroad Property adjacent to Area 2, where radiologically contaminated soil which eroded off of Area 2 will be removed and consolidated within Area 2. UMTRCA is an ARAR for this portion of the site because the conditions there are sufficiently similar to a mine tailings pile; UMTRCA provides the cleanup standards for this removal work. UMTRCA is not an ARAR for Areas 1 and 2 because a MSW landfill is not sufficiently similar to a mine tailings pile, however,UMTRCA provisions relating to design of a landfill cap which covers radiologically contaminated wastes along with MSW provide "to-be-considered (TBC)" criteria. Accordingly, consistent with UMTRCA, the cap design will includea rubble layer and the final caps on Areas 1 and 2 will meet the radon emission standards provided for in UMTRCA. UMTRCA is a remedy driver.

EPA has established Maximum Contaminant Levels (MCLs) and Maximum Contaminant Level Goals (MCLGs) pursuant to the Safe Drinking Water Act (40 CFR Part 141, Subparts F and G). Implementation of the requirements of the Safe Drinking Water Act has been delegated to the State of Missouri and is the subject of regulations promulgated by the MDNR. MCLs are ARARs for the Site as the alluvial aquifer beneath the landfill could act as a drinking water source. However, restrictive covenants prevent use of this aquifer at the Site. MCLs are not a remedy driver as no groundwater plume has been identified.

Executive Order 11988, 40 CFR 6.302(b) and the Missouri Governor's Order 82-19 relative to floodplain management are identified in the FS (EMSI, 2006) as potential location-specific ARARs relative to floodplain management. The Buffer Zone and Crossroad Property are located within the historic floodplain of the Missouri River. These areas are currently protected by the engineered Earth City levee and flood control system. These regulations are ARARs because Areas 1 and 2, the Buffer Zone and the Crossroad Property are located within the extent of the floodplain identified by the Federal Emergency Management Agency (FEMA). These regulations are remedy drivers as they impact portions of the cap design.

The ROD-selected remedy was developed and selected to provide engineered containment of the solid wastes and RIM contained in Areas 1 and 2. Because these areas contain solid wastes, the RCRA Subtitle D regulations and the MDNR Solid Waste Management Regulations represent the primary standards for design and implementation of a containment remedy. Specifically, the landfill cover design, gas control measures, maintenance, groundwater monitoring, and corrective action criteria of these regulations are potentially relevant and appropriate. These regulations are remedy drivers as they guide the cap design and set surface grading standards for drainage.

Technical and Policy Issues

The presence of principal threat waste at the Site will be addressed in the ROD amendment. The ROD unequivocally states that PTW is not present; however, HQ re-examined the 2008 ROD determination regarding principal threat waste and concluded that the soil-and-MSW mixture in OU1 is in fact principal threat waste, as there were such high levels of radioactive wastes, that should exposure occur, they would present a significant risk to human health or the environment.

Proximity of Areas 1 and 2 to the Lambert – St. Louis Airport will require coordination with Airport authorities on the issue of regrading existing materials (surface soil, MSW and radiologically-impacted material). The amount of material needed to be moved, and the time frame during which this material will be exposed, is much smaller than those contemplated in the excavation remedies. However, the Airport's restrictive covenant on the site prohibits "…new or additional depositing or dumping of municipal waste, organic waste, and/or putrescible waste (municipal waste, organic waste and putrescible waste hereinafter collectively referred to as "Putrescible Waste") above, upon, on, or under the Property beginning as of August 1, 2005 and continuing in perpetuity, unless and until such time as this Agreement is terminated or canceled by St. Louis…". EPA will discuss the applicability of this restrictive covenant to the regrading required by the selected remedy with the Airport and, if necessary, work to amend the restrictive covenant to allow the work.

The Airport wrote a letter during the 2006 public comment period on the Proposed Plan, in which it did not object to the ROD remedy of capping the waste in place; however, they requested the opportunity for further comment should EPA select a remedy which would involve exposing portions of the landfill waste.

The ROD remedy as described in the SFS differs slightly from the 2008 ROD remedy, in the areas of regrading of existing materials at Areas 1 and 2, and the rip-rap armoring of the toe of the Area 2 cap. The proposed plan and ROD amendment will address and explain these differences.

Cost Information

The SFS included an RD-level cost estimate of all three remedies evaluated therein. The summary of these costs, including capital, O&M, and present value costs, is provided above in the "Comparative Analysis of Alternatives" table above. The times to achieve RAOs are also displayed in this table and are calculated in two ways: first, based on the time required to do the work (with unconstrained funding provided by the PRP); and second, based on a $10M/yr funding stream from the Fund, in case the PRPs cannot be compelled to do the work themselves.

The full cost estimates are provided in Appendix K of the SFS. The methodology used to perform these cost estimates is provided in Section 6.1.7 of the SFS. These estimates are extremely detailed and cannot be adequately summarized here; however, some of the general information requested by the "Recommended Outline for the Site Information Package" can be provided.

The primary source of uncertainty in the cost estimates for both excavation alternatives is the volume of radiologically-impacted material (RIM) to be excavated. While the SFS provides detailed calculations of this volume, it is based on a relatively low density of borings through the waste mass. The volume of RIM could be significantly more than currently estimated.

A major source of uncertainty in the cost estimate for the excavation and off-site disposal remedy is the per-cubic-yard cost to transport and dispose the RIM to its off-site receiving facility. Neither of the potential receiving facilities evaluated in the SFS (U.S. Ecology's facility in Grandview, Idaho and

EnergySolutions' facility in Clive, Utah) were willing to provide a detailed cost estimate for the purposes of the SFS, only providing a round number for "turn-key" services of waste transportation and disposal. Furthermore, the two facilities provided very different costs for this service.

A major source of uncertainty in the cost estimate for the excavation and on-site disposal remedy is whether the proposed location for the new cell is truly large enough to accept all of the RIM. If the cell is constructed and filled and additional RIM remains to be excavated, that extra RIM would have to be shipped off-site at considerable additional cost.

Other sources of uncertainty applicable to all three SFS remedial alternatives are the costs of materials to construct the caps; the labor costs, particularly with respect to radiological screening and environmental monitoring during the work; costs to excavate, whether to consolidate material on-site, or to dispose of material on-site or off-site as the volume of material excavated includes a swell factor; costs associated with bird mitigation.

The discount rate used for NPV calculations is 2.3% (see SFS Section 6.1.7.3).

Cost data were obtained from a variety of sources including cost estimating guides and references such as unit prices in the latest RS Means Heavy Construction and Sitework & Landscaping Cost Data, RS Means CostWorks First Quarter 2011 digital cost data, site-specific vendor and contractor quotes and discussions, experience with actual costs from similar projects, other historical project costs updated to 2011 costs using the Engineering News Record Construction Cost Index (ENR CCI), and engineering judgment.

Letters from Stakeholders and State

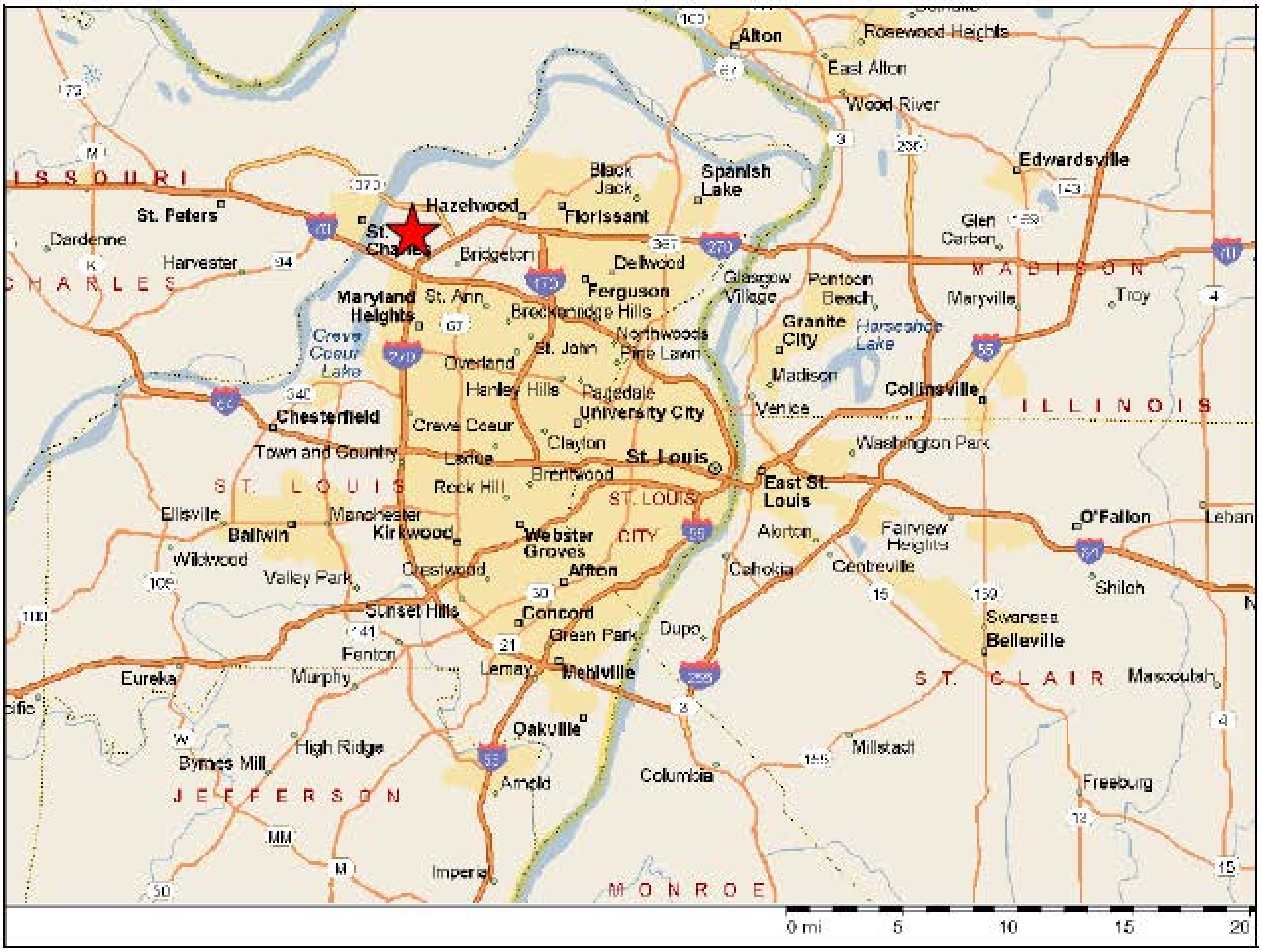
No public comment has been taken on the SFS report, which was finalized in December 2011. The State provided numerous comments on the several drafts of the SFS report but did not express an official preference for any of the three remedies evaluated therein.

Numerous letters from the public as well as comments during public meetings were received during the ROD public comment periods and are summarized in the Responsiveness Summary to the ROD. The State did officially support the ROD remedy in a letter dated December 28, 2006 which is part of the attachments to the Responsiveness Summary. This letter states in part:

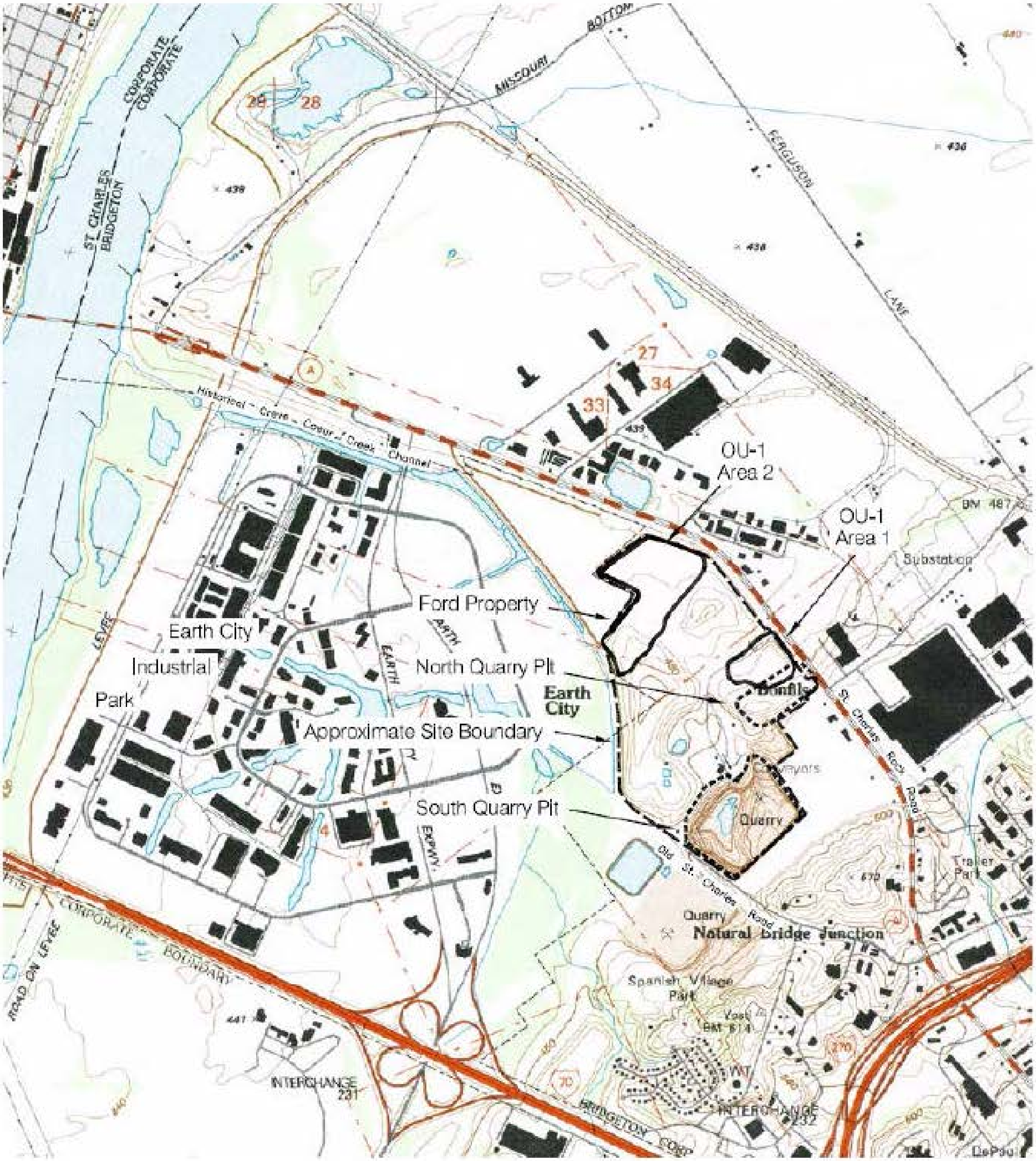
"The department has reviewed the proposed plan and, in general, supports remediation that will provide containment and isolation from human receptors and the environment, such as that proposed in Alternative L4 for Operable Unit 1, Alternative F4 for the Buffer Zone, and Alternative 2 for Operable Unit 2. The department also recognizes the need for long-term care and monitoring and insists that a robust and durable stewardship plan be implemented to address this aspect. In order to achieve this, the state has applicable standards that are relevant and appropriate for:

- Closure and long-term care of all portions of the site
- Monitoring and control of gas generated in the waste deposits
- Monitoring of groundwater
- Continued removal of leachate from the formerly active sanitary landfill"

FIGURE 1-1 SITE LOCATION



★ **Site Location**



Source: St. Charles, MO USGS
7.5' Quadrangle, 1994

2000 0 2000

SCALE IN FEET

N

FIGURE 1-2

Site Vicinity Map

West Lake Landfill OU-1 Feasibility Study

EMSI Engineering Management Support, Inc.

M:\clients\EMSI\westlake\11-04\fig-2-4-Site Layout.dwg plotted: 04/05/2005

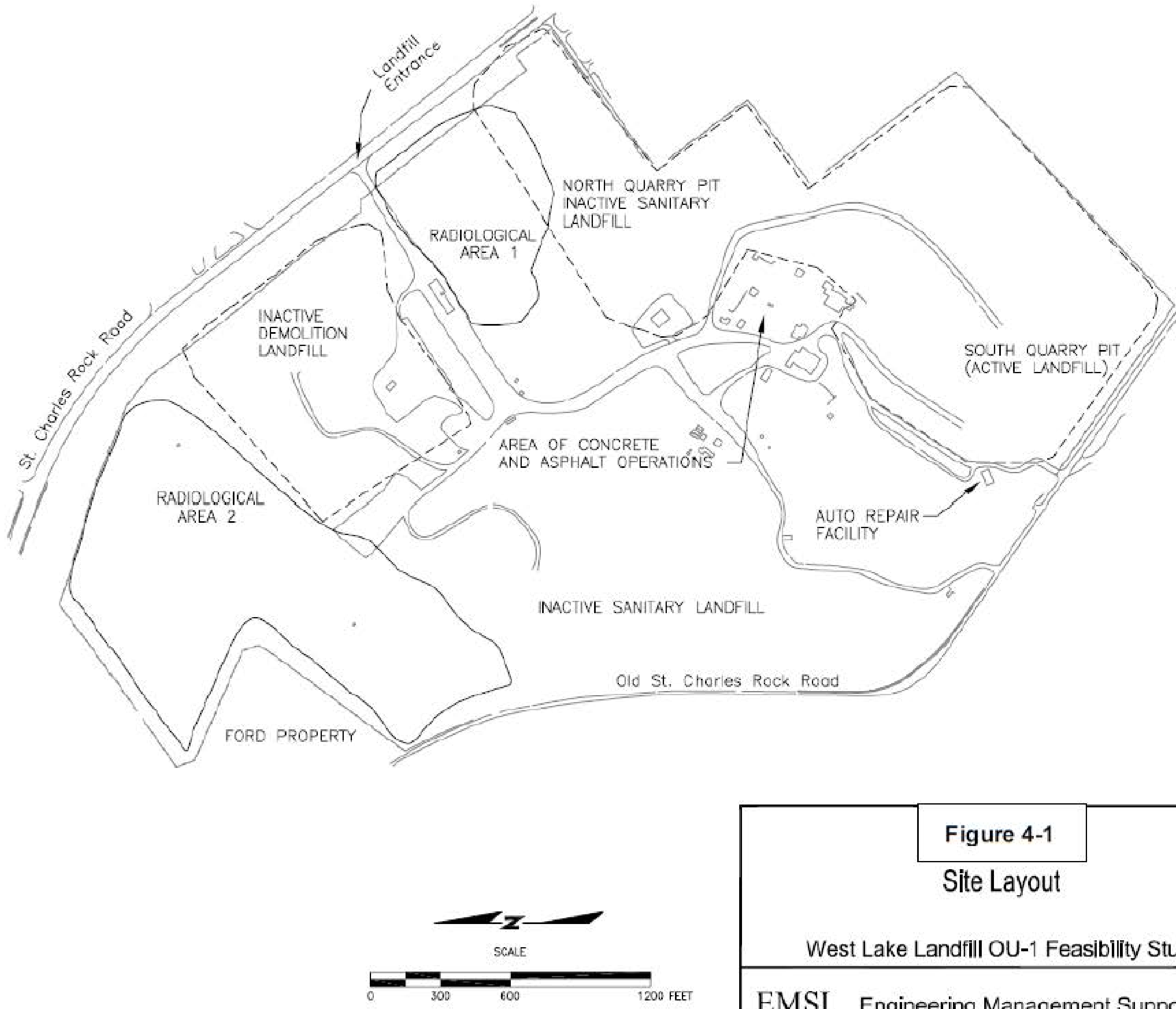
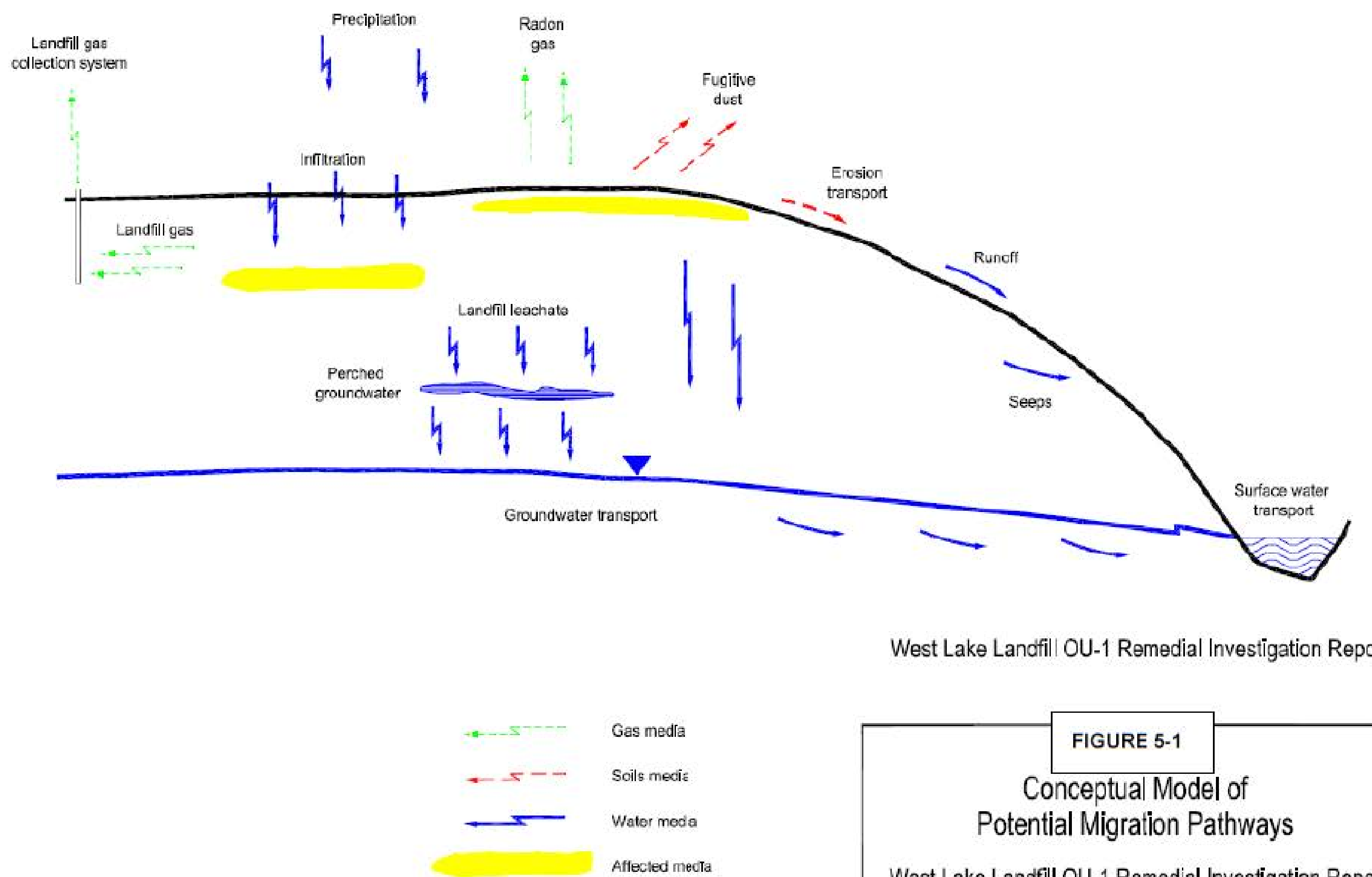


Figure 4-1

Site Layout

West Lake Landfill OU-1 Feasibility Study

EMSI Engineering Management Support, Inc.



West Lake Landfill OU-1 Remedial Investigation Report

FIGURE 5-1

Conceptual Model of Potential Migration Pathways

West Lake Landfill OU-1 Remedial Investigation Report

EMSI Engineering Management Support, Inc.

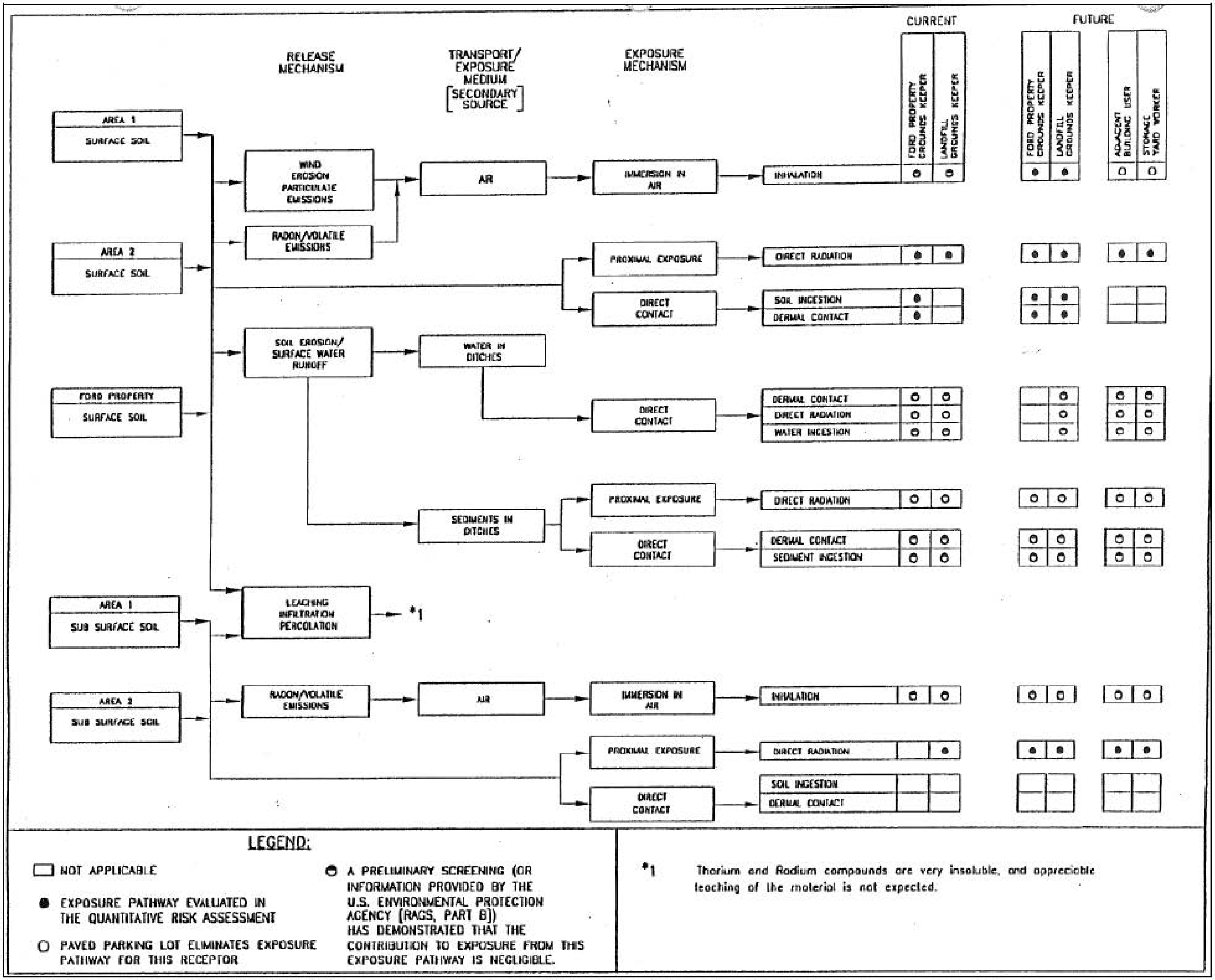


FIGURE 5-2 CONCEPTUAL SITE MODEL

Table 5-2: Summary of Radionuclide Occurrence Above Reference Levels in Area 1 Surface Samples

Radiological Constituents	Background Value (mean + 2 std. dev.)	> Background but < Reference # Detects	Range	Reference Level	> Reference Level # Detects	Range
Uranium – 238 Decay Series						
Uranium-238	2.24	1	2.33+/-0.54	7.24	2	87+/-7.2 to 147+/-38
Thorium-234	2.76	0		7.76	2	55.9+/-13.5 to 180+/-49
Uranium-234	2.73	1	2.94+/-0.65	7.73	2	105+/- 22 to 154+/-40
Thorium-230	2.45	1	2.67+/-0.76	7.45	2	7,850+/-1,470 to 57,000 +/-4,100
Radium-226	1.30	1	1.32+/-0.24	6.3	2	109+/-5 to 910+/-93
Lead-214	1.13	3	1.16+/-0.44 to 1.62+/-0.56	6.13	2	108+/-8 to 1,100+/-99
Bismuth-214	1.61	0		6.61	2	110+/-6 to 1,000+/-57
Lead-210	3.77	0		8.77	3	206+/-26 to 1,040+/-135
Uranium – 235 Decay Series						
Uranium-235/236	1.15	1	5.7+/-1.9	6.15	2	6.86+/-3.99 to 19.5+/-5.9
Proactinium-231	NE	NE	NE	5	2	156+/-27 to 610+/-110
Actinium-227	NE	NE	NE	5	2	118+/-14 to 305+/-33
Radium-223	NE	NE	NE	5	2	113+/-NA to 939+/-76
Thorium – 232 Decay Series						
Thorium-232	1.55	0		6.55	2	18.1+/-4.6 to 40+/-150
Radium-228	2.37	0		7.37	0	
Thorium-228	1.33	1	1.96+/-1.14	6.33	0	
Radium-224	NE	NE	NE	5	1	1,760+/-219
Lead-212	2.26	0		7.26	0	
Bismuth-212	NE	NE	NE	5	0	
Thallium-208	0.71	1	0.79+/-0.83	5.71	1	6.8+/-2.1

All values expressed as pCi/g.
NE = Not established, all background samples below minimum detectable activity. NA = 2 Sigma Error (+/-) is not available.
A total of 8 surface soil samples were collected in Area 1. One of the samples was split and analyzed at two different laboratories. For some of the radionuclides, the results from one of the laboratories were greater than the background or reference levels, while the results from the second laboratory were not.

Table 5-3: Summary of Radionuclide Occurrence Above Reference Levels in Area 1 Subsurface Samples

Radiological Constituents	Background Value (mean + 2 std. dev.)	> Background but < Reference		Reference Level	> Reference Level	
		# Detects	Range		# Detects	Range
Uranium – 238 Decay Series						
Uranium-238	2.24	5	2.89+/-0.56 to 6.94+/-1.28	17.24	2	17.8+/-4.1 to 26.4+/-10.1
Thorium-234	2.76	0		17.76	0	
Uranium-234	2.73	6	2.92+/-1.46 to 15.6+/-3.6	17.73	0	
Thorium-230	2.45	6	2.47+/-1.26 to 7.52+/-1.65	17.45	6	23.2+/-4.9 to 1,500+/-240
Radium-226	1.30	6	1.36+/-0.37 to 6.3+/-1.2	16.3	3	18.4+/-1 to 128+/-6
Lead-214	1.13	12	1.13+/-0.33 to 7.0+/-0.76	16.13	3	19.9+/-1.6 to 110+/-7
Bismuth-214	1.61	3	2.53+/-0.19 to 6.5+/-0.58	16.61	3	18.4+/-1.2 to 128+/-7.00
Lead-210	3.77	2	5.1+/-1.0 to 17+/-4.0	18.77	2	83.4+/-12.4 to 212+/-28
Uranium – 235 Decay Series						
Uranium-235/236	1.15	1	1.46+/-0.57	16.15	0	
Proactinium-231	NE	NE	NE	15	3	26.9+/-7.9 to 73.2+/-14.6
Actinium-227	NE	NE	NE	15	3	15.0+/-2.6 to 43.8+/-5.8
Radium-223	NE	NE	NE	15	3	16.1+/-NA to 44.3+/-NA
Thorium – 232 Decay Series						
Thorium-232	1.55	4	1.64+/-0.56 to 10.3+/-3.5	16.55	0	
Radium-228	2.37	0		17.37	0	
Thorium-228	1.33	1	1.55+/-1.48	16.33	0	
Radium-224	NE	NE	NE	15	1	39.1+/-6.3
Lead-212	2.26	0		17.26	0	
Bismuth-212	NE	NE	NE	15	0	
Thallium-208	0.71	0		15.71	0	

All values expressed as pCi/g.
NE = Not established, all background samples below minimum detectable activity. NA = 2 Sigma Error (+/-) is not available.
A total of 39 subsurface soil samples were collected in Area 1. Field and laboratory duplicates were prepared for several of the samples. Two of the samples were split and analyzed at two different laboratories. For some of the radionuclides, the results from one of the laboratories or from one of the duplicate samples were greater than the background or reference levels, while the results from the original sample or second laboratory were not.

Table 5-4: Summary of Radionuclide Occurrence Above Reference Levels in Area 2 Surface Samples

Radiological Constituents	Background Value (mean + 2 std. dev.)	> Background but < Reference # Detects	Range	Reference Level	> Reference Level # Detects	Range
Uranium 238 – Decay Series						
Uranium-238	2.24	3	3.1+/-0.7 to 4.17+/-1.04	7.24	2	134+/-42 to 294+/-92
Thorium-234	2.76	0		7.76	0	
Uranium-234	2.73	3	3.18+/-1.06 to 4.05+/-1.02	7.73	2	216+/-67 to 575+/-180
Thorium-230	2.45	4	2.91+/-0.82 to 5.35+/-1.14	7.45	9	8.63+/-2.62 to 29,240+/-5,290
Radium-226	1.30	4	1.54+/-0.22 to 4.78+/-0.44	6.3	4	9.2+/-1.7 to 3,720+/-142
Lead-214	1.13	5	1.28+/-0.28 to 5.26+/-0.49	6.13	4	8.8+/-1.0 to 3,190+/-277
Bismuth-214	1.61	2	3.56+/-0.87 to 4.2+/-0.67	6.61	4	7.3+/-0.69 to 3,690+/-136
Lead-210	3.77	0		8.77	3	9.58+/-2.32 to 1,370+/-162
Uranium – 235 Decay Series						
Uranium-235/236	1.15	0		6.15	2	49.7+/-16.5 to 251+/-79
Proactinium-231	NE	NE	NE	5	4	5.22+/-2.32 to 2,030+/-301
Actinium-227	NE	NE	NE	5	3	6.15+/-1.17 to 1,320+/-179
Radium-223	NE	NE	NE	5	3	6.73+/-NA to 1,097+/-NA
Thorium – 232 Decay Series						
Thorium-232	1.55	0		6.55	4	6.73+/-1.36 to 127+/-23
Radium-228	2.37	0		7.37	0	
Thorium-228	1.33	1	4.97+/-1.04	6.33	0	
Radium-224	NE	NE	NE	5	2	4,330+/-628 to 6,580+/-1090
Lead-212	2.26	0		7.26	0	
Bismuth-212	NE	0		5	0	
Thallium-208	0.71	0		5.71	0	

All values expressed as pCi/g.

NE = Not established, all background samples below minimum detectable activity. NA = 2 Sigma Error (+/-) is not available.

A total of 15 surface soil samples were collected in Area 2. Three of the samples were split and analyzed at two different laboratories. For some of the radionuclides, the results from one of the laboratories were greater than the background or reference levels, while the results from the second laboratory were not.

Table 5-5: Summary of Radionuclide Occurrence Above Reference Levels in Area 2 Subsurface Samples

Radiological Constituents	Background Value (mean + 2 std. dev.)	Background but < Reference # Detects	Background but < Reference Range	Reference Level	> Reference Level # Detects	> Reference Level Range
Uranium – 238 Decay Series						
Uranium-238	2.24	7	2.61+/-0.64 to 11.4+/-3.8	17.24	3	60.7+/-12.4 to 287+/-47
Thorium-234	2.76	1	13.2+/-15.7	17.76	2	24.5+/-15.8 to 140+/-25
Uranium-234	2.73	6	2.9+/-0.4 to 12.5+/-4.0	17.73	3	45.4+/-9.7 to 527+/-87
Thorium-230	2.45	28	2.72+/-1.45 to 17.29+/-3.4	17.45	18	18.2+/-3.3 to 83,000+/-530
Radium-226	1.30	17	1.3+/-0.45 to 12.9+/-0.54	16.3	4	88.4+/-5.2 to 3,140+/-116
Lead-214	1.13	23	1.14+/-0.24 to 12.5+/-0.9	16.13	4	85.9+/-6.4 to 2,200+/-170
Bismuth-214	1.61	10	1.63+/-0.42 to 12.6+/-0.6	16.61	4	93.2+/-5.1 to 3,150+/-111
Lead-210	3.77	7	4.02+/-1.6 to 9.83+/-2.56	18.77	6	22.4+/-3.5 to 1,300+/-157
Uranium – 235 Decay Series						
Uranium-235/236	1.15	0		16.15	3	24+/-27 to 115+/-19
Proactinium-231	NE	NE	NE	15	4	39.3+/-11.1 to 1,930+/-243
Actinium-227	NE	NE	NE	15	4	25.8+/-4.2 to 1,180+/-138
Radium-223	NE	NE	NE	15	4	30.2+/-NA to 5,270+/-359
Thorium – 232 Decay Series						
Thorium-232	1.55	4	1.76+/-1.07 to 3.84+/-0.9	16.55	3	106+/-19 to 180+/-65
Radium-228	2.37	2	14.5+/-7.9 to 16.7+/-9.3	17.37	0	
Thorium-228	1.33	2	1.5+/-0.80 to 4.59+/-0.91	16.33	0	
Radium-224	NE	NE	NE	15	0	
Lead-212	2.26	1	2.49+/-0.94	17.26	1	82+/-35
Bismuth-212	NE	NE	NE	15	0	
Thallium-208	0.71	3	1.13+/-0.78 to 7.9+/-3.7	15.71	0	

All values expressed as pCi/g.

NE = Not established, all background samples below minimum detectable activity. NA = 2 Sigma Error (+/-) is not available.

A total of 73 subsurface soil samples were collected in Area 2. Field and laboratory duplicates were prepared for several of the samples. Four of the samples were split and analyzed at two different laboratories. For some of the radionuclides, the results from one of the laboratories or from one of the duplicate samples were greater than the background or reference levels, while the results from the original sample or second laboratory were not.

Table 5-6: Summary of Background Radionuclide Levels at the West Lake Landfill Site

Radionuclide	Detection Frequency	Mean	Standard Deviation	Minimum Value	Maximum Value	Mean Plus 2 Standard Deviations	Mean Plus 3 Standard Deviations	Variance
Uranium-238 Decay Series								
Uranium-238	4/4	1.33	0.46	0.74+/-0.35	1.85+/-0.79	2.24	2.7	0.21
Thorium-234	2/4	1.57	0.59	1.15+/-0.89	1.99+/-1.11	2.76	3.35	0.35
Uranium-234	4/4	1.47	0.63	1.06+/-0.44	2.40+/-0.93	2.73	3.36	0.40
Thorium-230	4/4	1.51	0.47	0.92+/-0.44	2.03+/-0.6	2.45	2.91	0.22
Radium-226	4/4	1.06	0.12	0.95+/-0.22	1.19+/-0.22	1.30	1.41	0.01
Lead-214	4/4	1.01	0.06	0.92+/-0.26	1.07+/-0.24	1.13	1.19	0.004
Bismuth-214	2/4	1.09	0.26	0.90+/-0.31	1.27+/-0.4	1.61	1.87	0.07
Lead-210	3/4	2.48	0.64	1.88+/-1.56	3.16+/-2.18	3.77	4.41	0.41
Uranium-235 Decay Series								
Uranium-235/236	4/4	0.39	0.38	0.02+/-0.08	0.91+/-0.57	1.15	1.54	0.15
Uranium-235	--	--	--	--	--	--	--	--
Protactinium-231	--	--	--	--	--	--	--	--
Actinium-227	--	--	--	--	--	--	--	--
Radium-223	--	--	--	--	--	--	--	--
Thorium-232 Decay Series								
Thorium-232	4/4	0.90	0.33	0.52+/-0.29	1.26+/-0.39	1.55	1.87	0.11
Radium-228	2/4	1.65	0.36	1.39+/-0.4	1.90+/-0.47	2.37	2.73	0.13
Thorium-228	4/4	0.68	0.33	0.43+/-0.27	1.16+/-0.37	1.33	1.66	0.11
Radium-224	--	--	--	--	--	--	--	--
Lead-212	4/4	1.29	0.48	0.80+/-0.31	1.94+/-0.29	2.26	2.74	0.23
Bismuth-212	--	--	--	--	--	--	--	--
Thallium-208	4/4	0.44	0.14	0.32+/-0.16	0.63+/-0.21	0.71	0.84	0.02

All values expressed as pCi/g, except detection frequency.

Four background samples were analyzed. Samples without detections were not used to calculate background statistics.

-- = Radionuclides were not detected above the Minimum Detectable Activity (MDA) in any of the four background samples.

M:\clients\EMSI\westlake\2011\Final-SFS\WL-Fig-14-Buffer Zone.dwg plotted: 09/28/2011

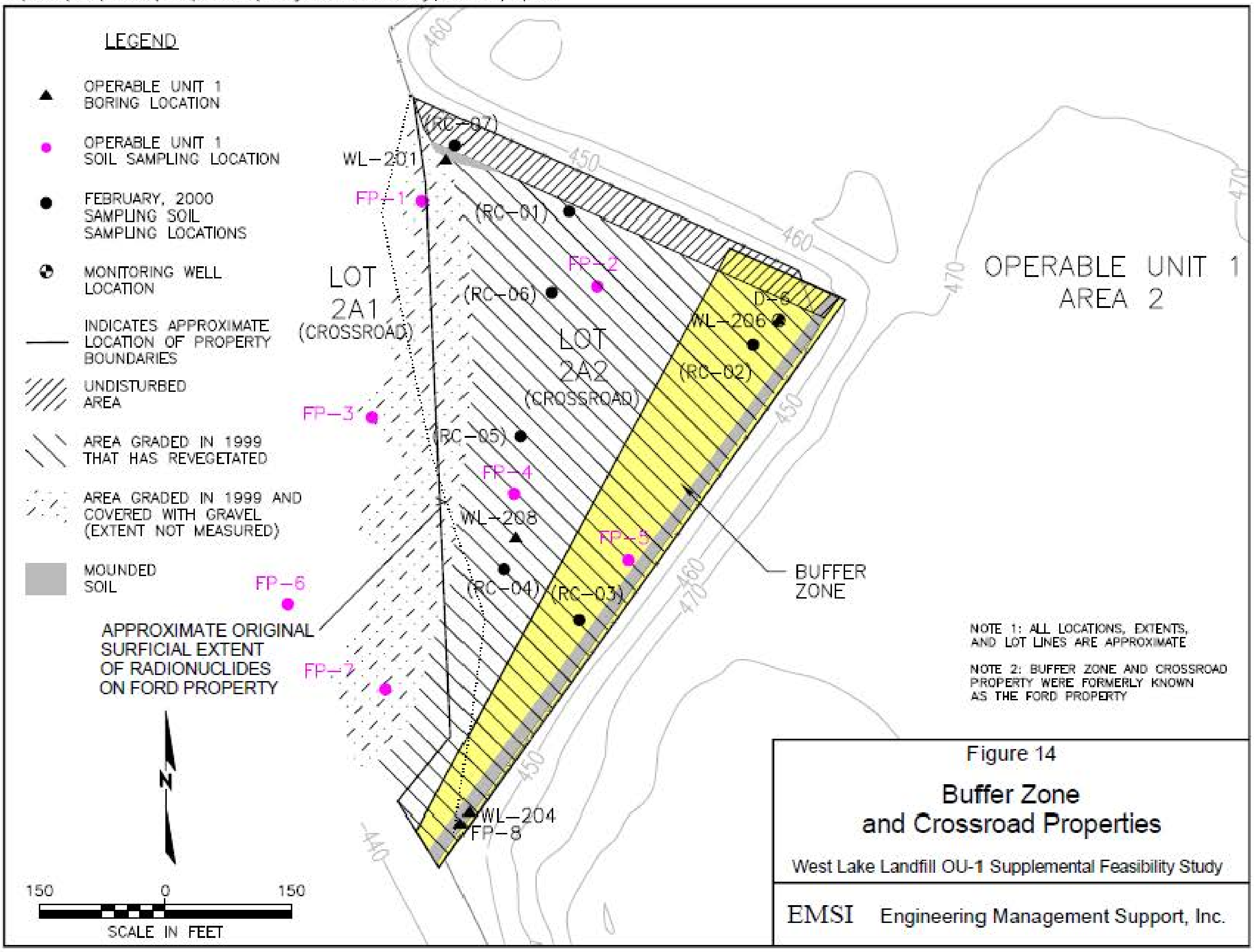


Figure 14

Buffer Zone and Crossroad Properties

West Lake Landfill OU-1 Supplemental Feasibility Study

EMSI Engineering Management Support, Inc.

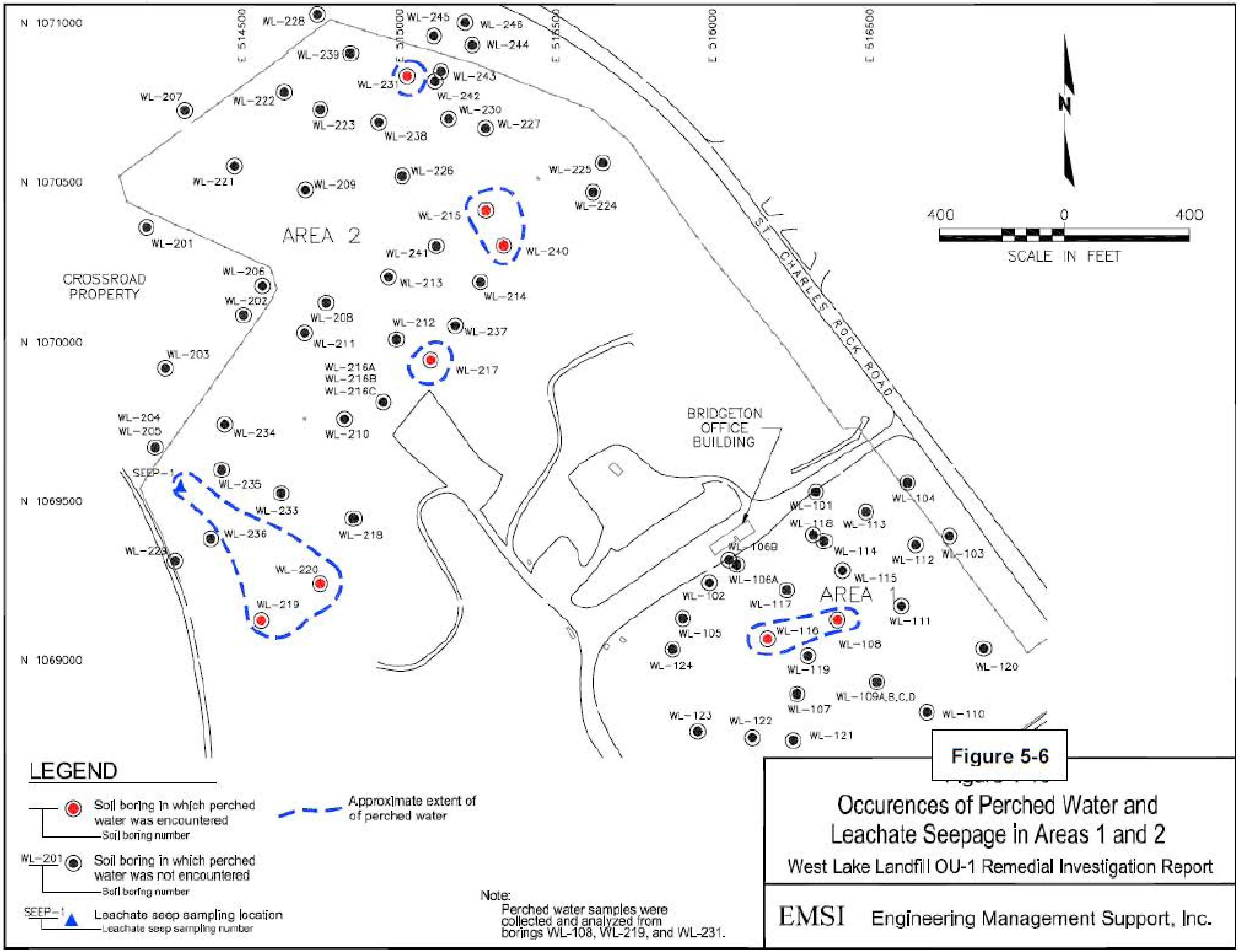


Figure 5-6

Occurences of Perched Water and Leachate Seepage in Areas 1 and 2

West Lake Landfill OU-1 Remedial Investigation Report

EMSI Engineering Management Support, Inc.

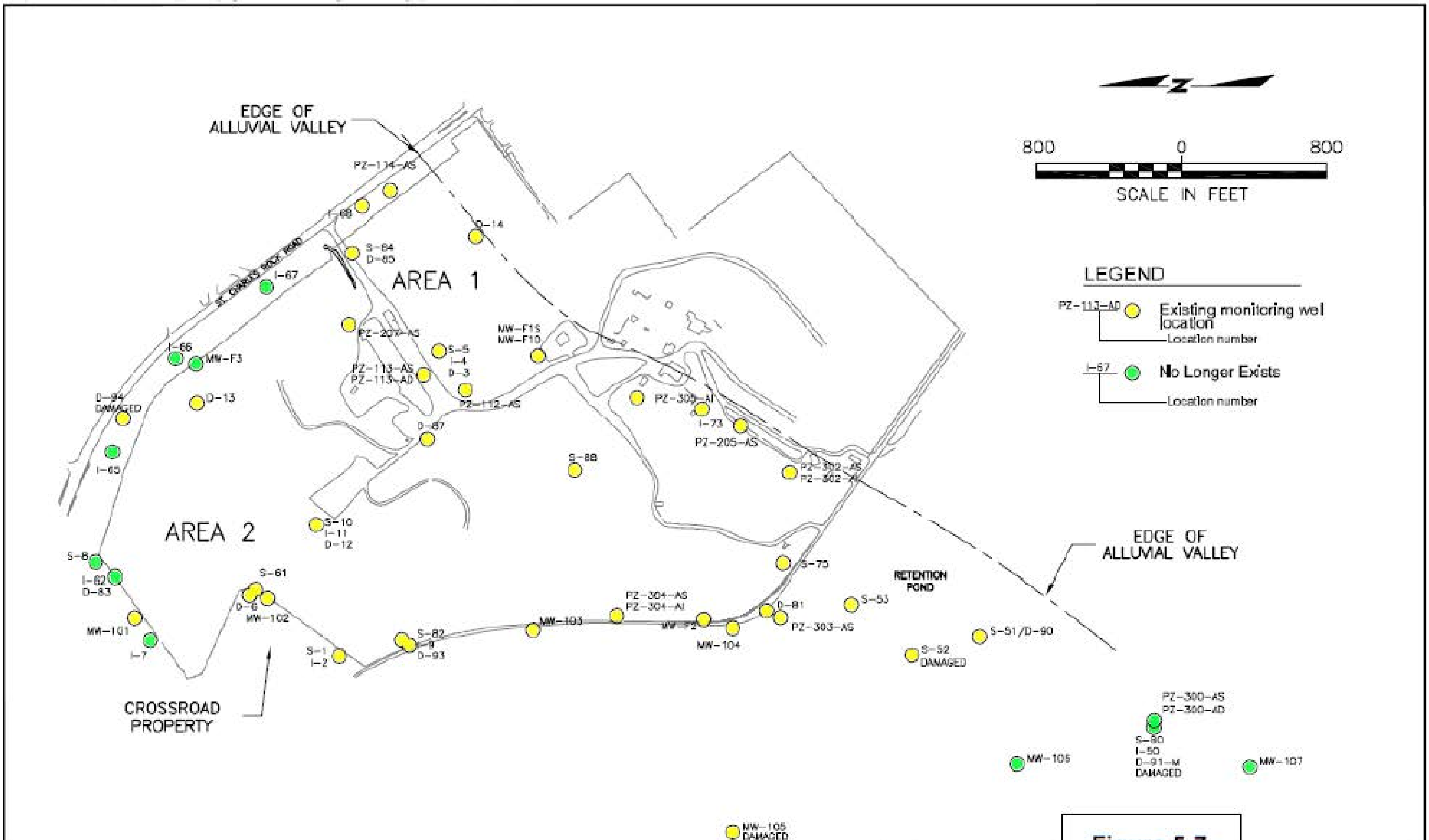


Figure 5-7

Groundwater Monitoring Well Locations

West Lake Landfill OU-1 Feasibility Study

EMSI Engineering Management Support, Inc.

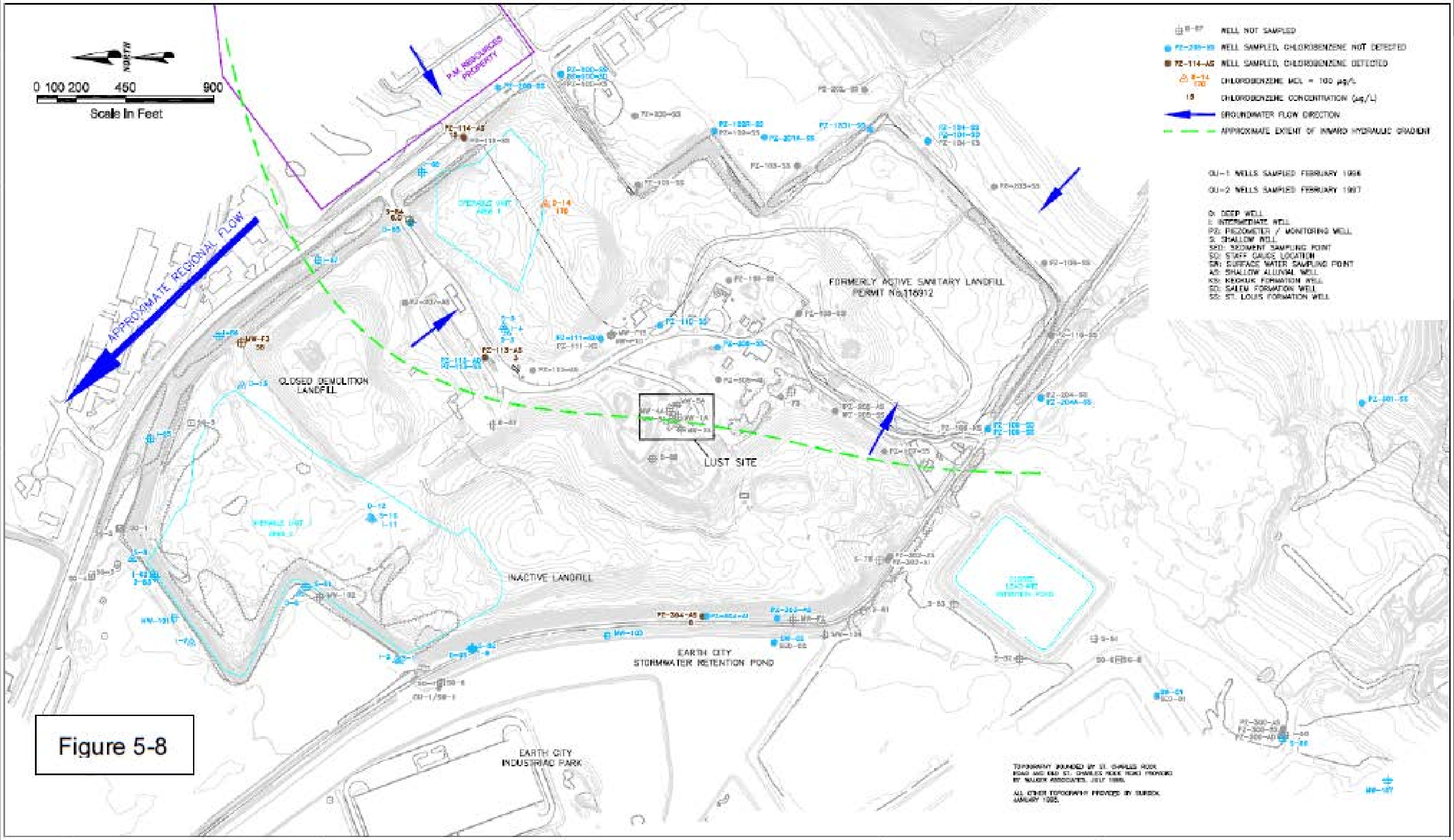


Figure 5-8

HERST & ASSOCIATES, INC.®

West Lake Landfill
Bridgeton, Missouri

Groundwater and Surface Water Chlorobenzene Results

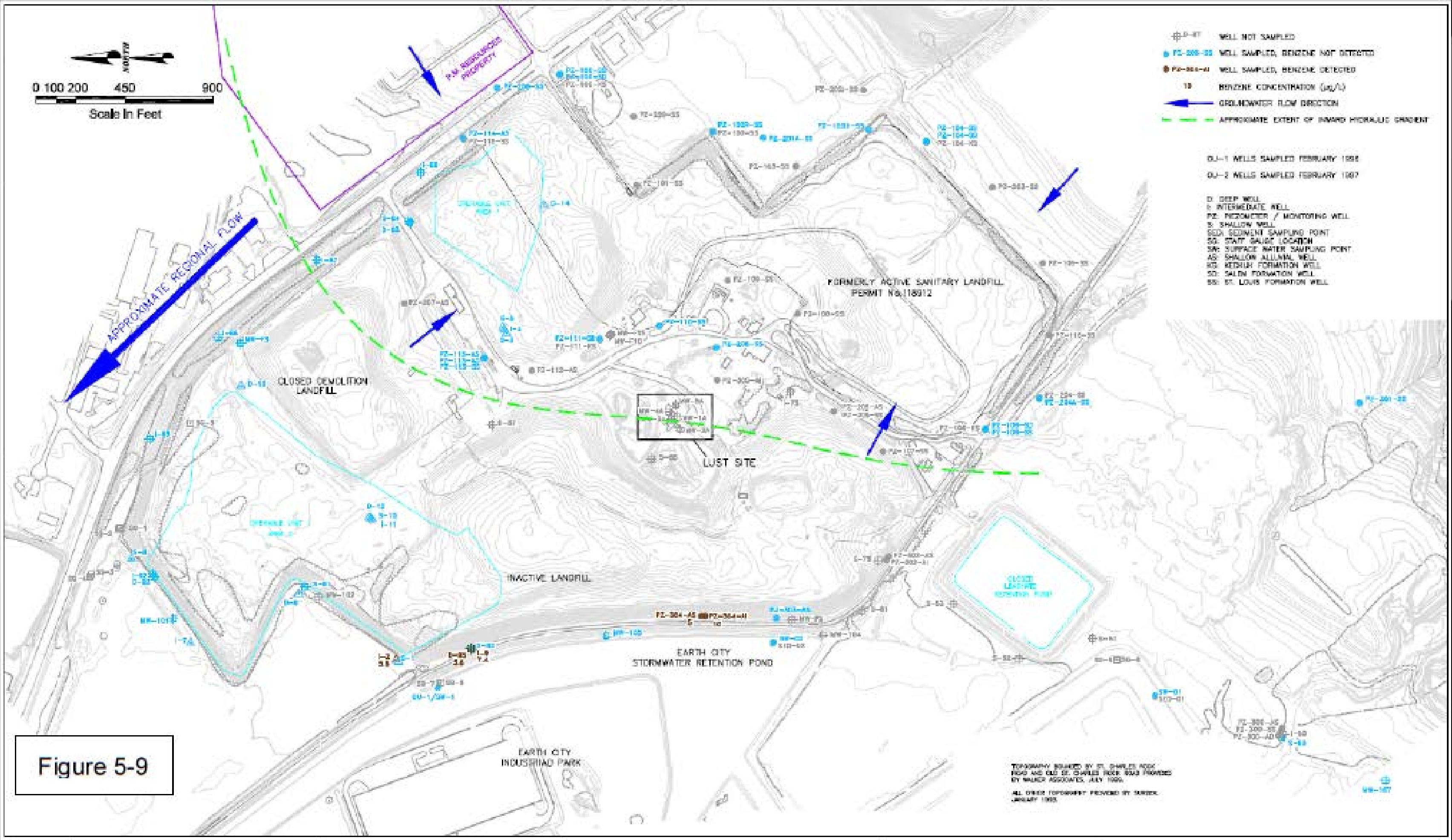


Figure 5-9

HERST & ASSOCIATES, INC.®

West Lake Landfill
Bridgeton, Missouri

Groundwater and Surface Water
Benzene Results

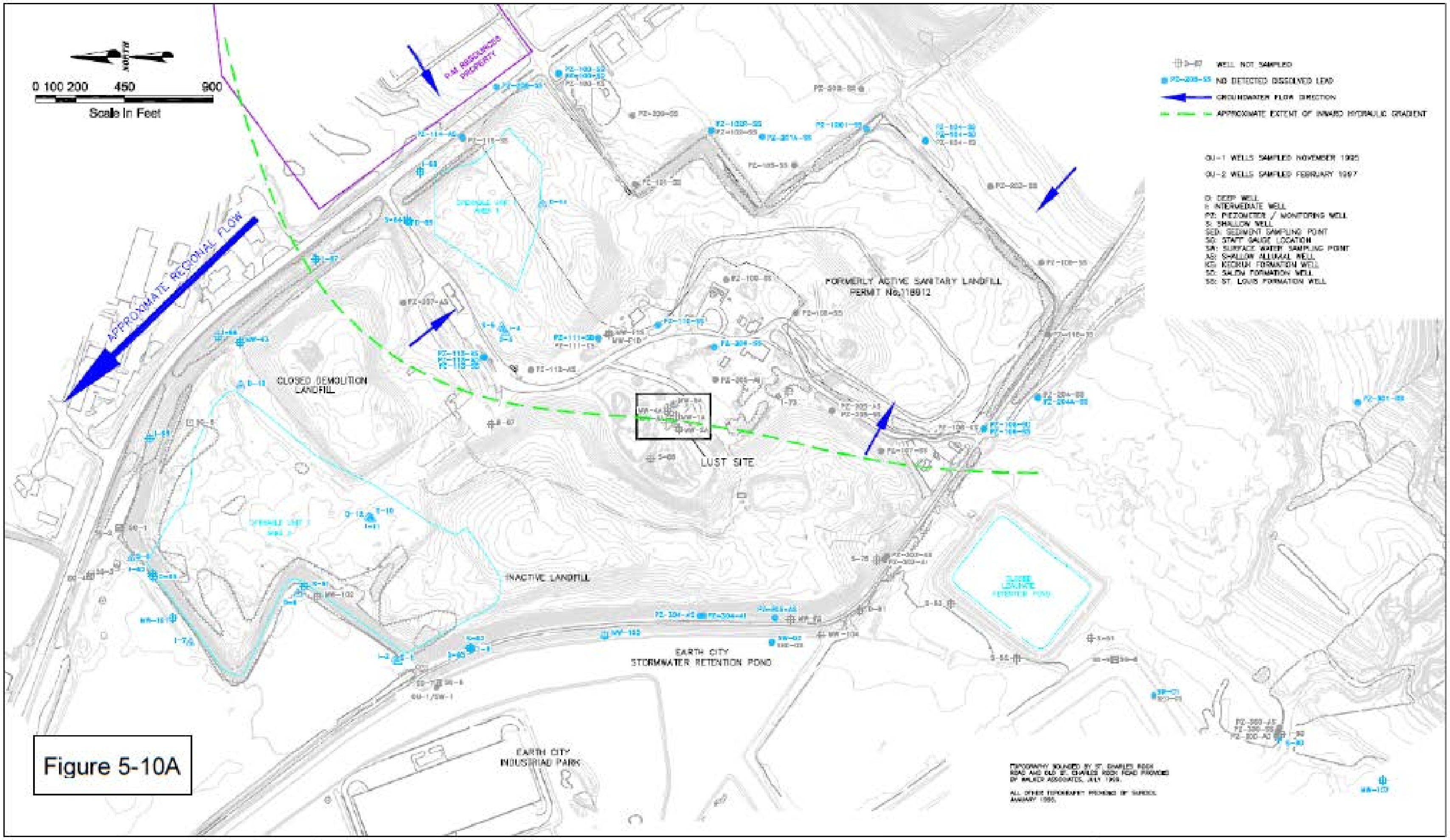


Figure 5-10A

HERST & ASSOCIATES, INC.®

West Lake Landfill
Bridgeton, Missouri

Groundwater and Surface Water
Dissolved Lead Results

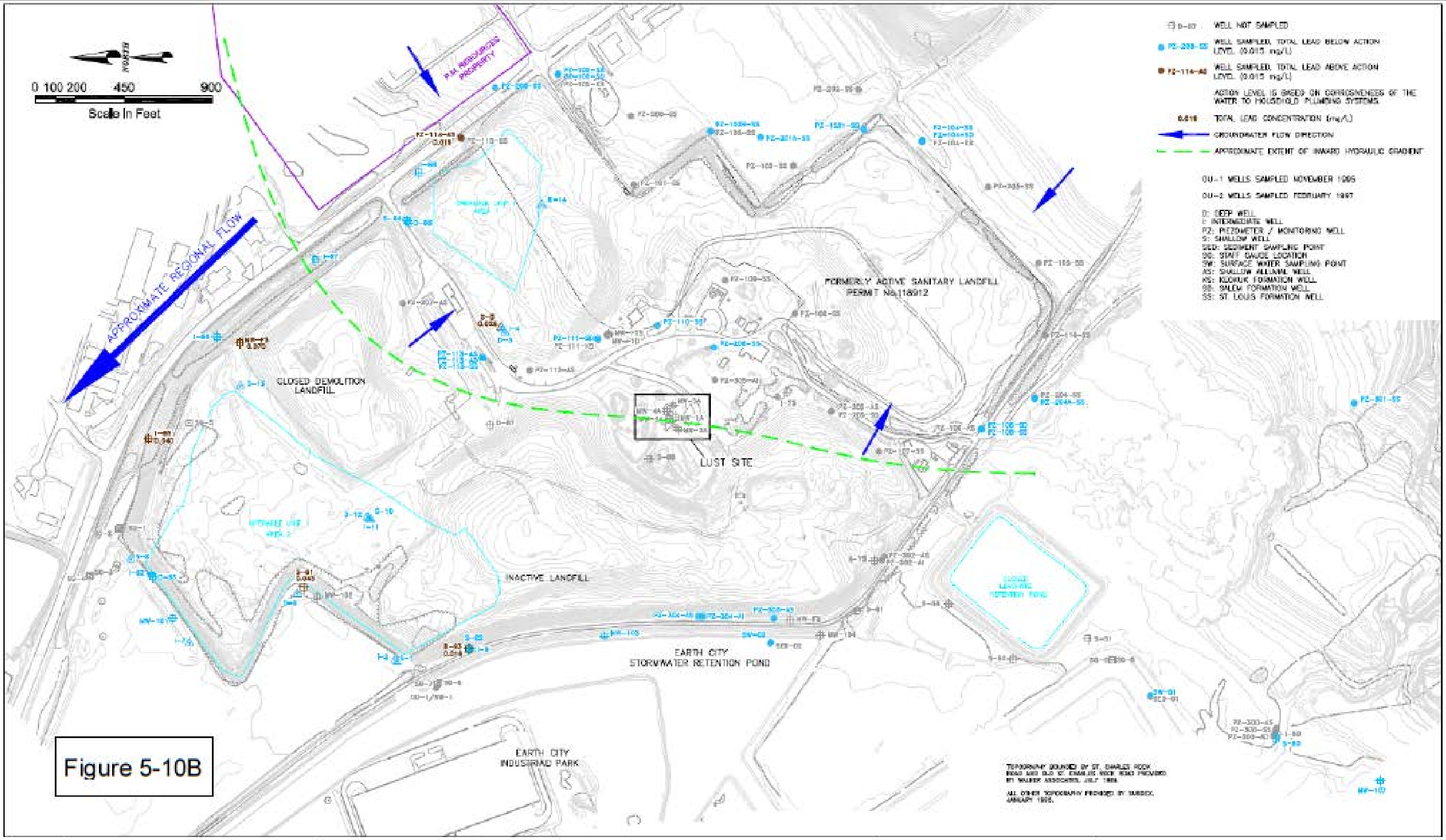
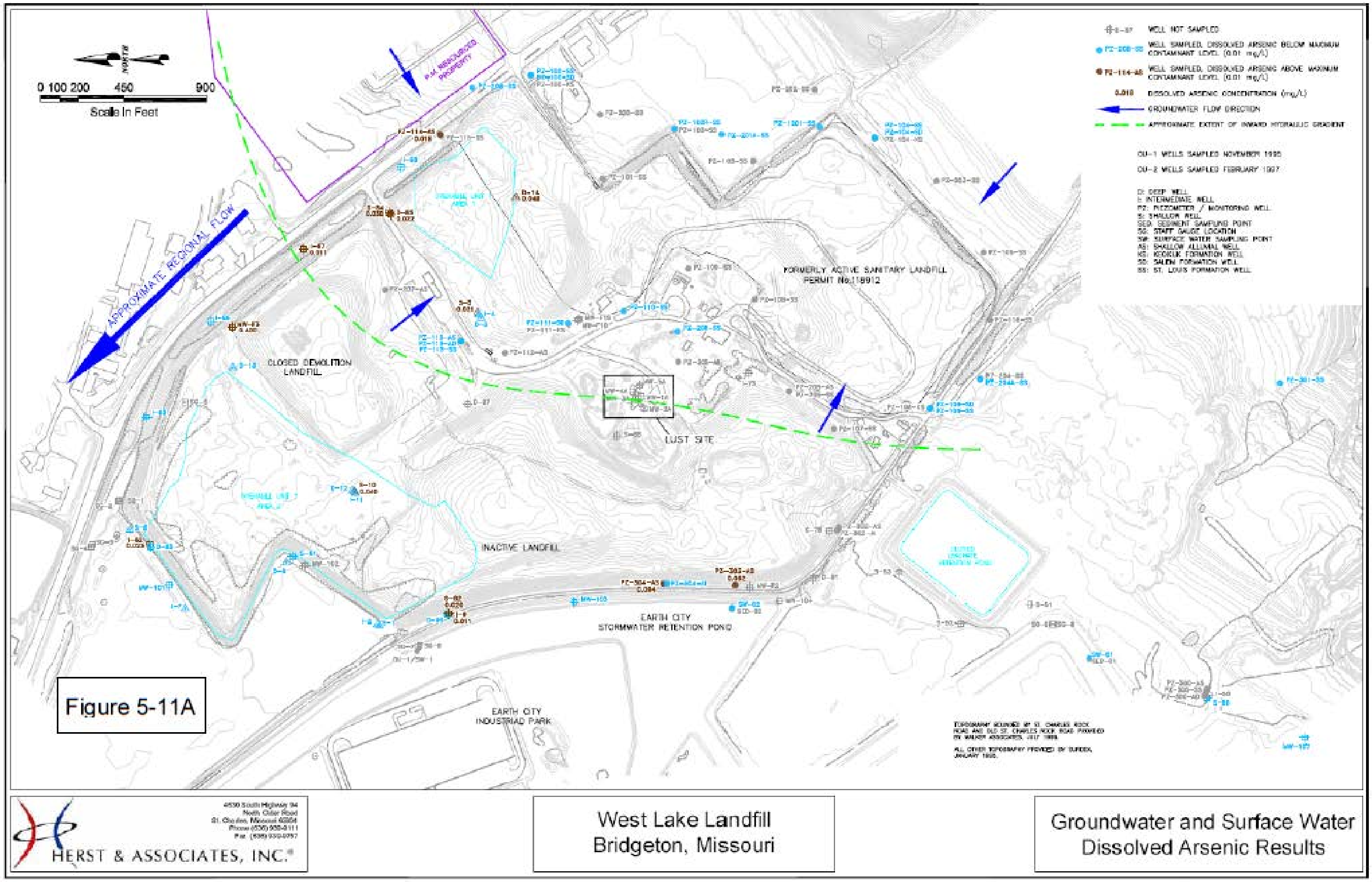


Figure 5-10B

HERST & ASSOCIATES, INC.®

West Lake Landfill
Bridgeton, Missouri

Groundwater and Surface Water
Total Lead Results



WELL NOT SAMPLED
WELL SAMPLED, DISSOLVED ARSENIC BELOW MAXIMUM CONTAMINANT LEVEL (0.01 mg/L)
WELL SAMPLED, DISSOLVED ARSENIC ABOVE MAXIMUM CONTAMINANT LEVEL (0.01 mg/L)
DISSOLVED ARSENIC CONCENTRATION (mg/L)
GROUNDWATER FLOW DIRECTION
APPROXIMATE EXTENT OF INWARD HYDRAULIC GRADIENT
OU-1 WELLS SAMPLED NOVEMBER 1995
OU-2 WELLS SAMPLED FEBRUARY 1997
D: DEEP WELL
I: INTERMEDIATE WELL
PZ: PIEZOMETER / MONITORING WELL
S: SHALLOW WELL
SED: SEDIMENT SAMPLING POINT
SG: STAFF GAUGE LOCATION
SW: SURFACE WATER SAMPLING POINT
AS: SHALLOW ALLUVIAL WELL
KS: KEOKUK FORMATION WELL
SS: SALEM FORMATION WELL
SS: ST. LOUIS FORMATION WELL
NORTH
0 100 200 450 900
Scale In Feet
APPROXIMATE REGIONAL FLOW
CLOSED DEMOLITION LANDFILL
FORMERLY ACTIVE SANITARY LANDFILL
PERMIT No. 118912
LUST SITE
INACTIVE LANDFILL
EARTH CITY
STORMWATER RETENTION POND
EARTH CITY
INDUSTRIAL PARK
Figure 5-11A
HERST & ASSOCIATES, INC.
West Lake Landfill
Bridgeton, Missouri
Groundwater and Surface Water
Dissolved Arsenic Results

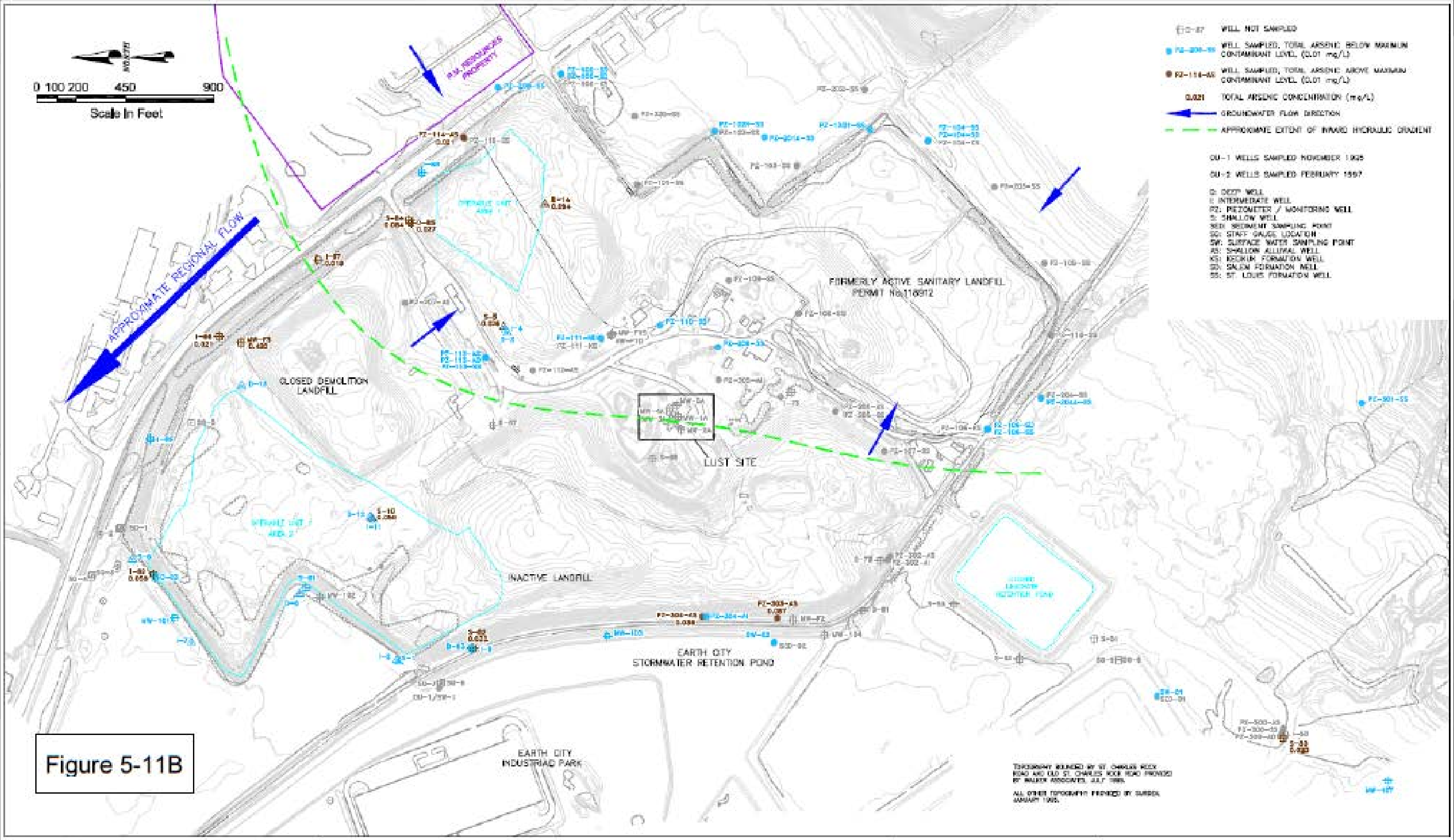


Figure 5-11B

HERST & ASSOCIATES, INC.®

West Lake Landfill
Bridgeton, Missouri

Groundwater and Surface Water Total Arsenic Results

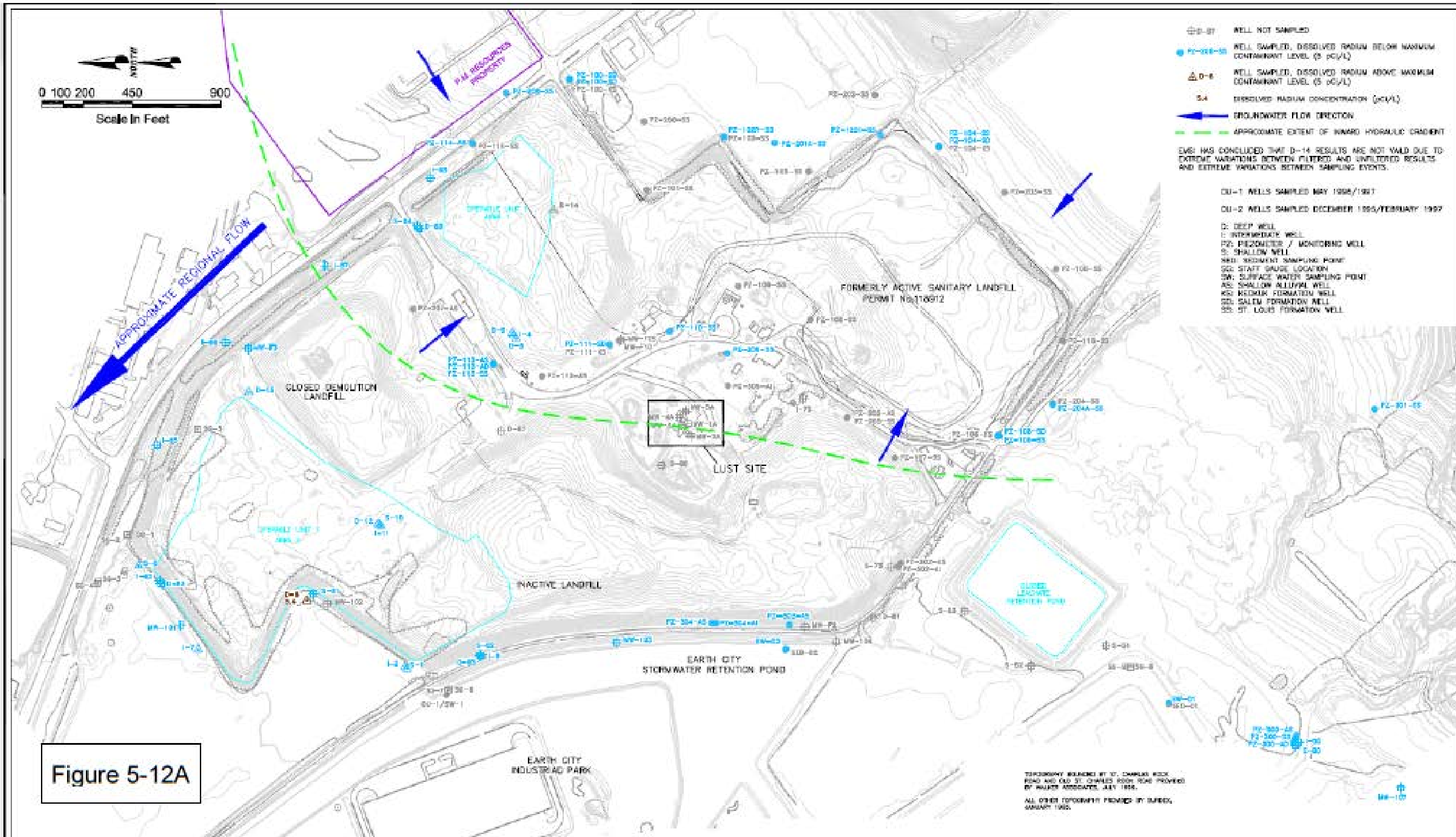


Figure 5-12A

HERST & ASSOCIATES, INC.®

West Lake Landfill
Bridgeton, Missouri

Groundwater and Surface Water Dissolved Radium Results

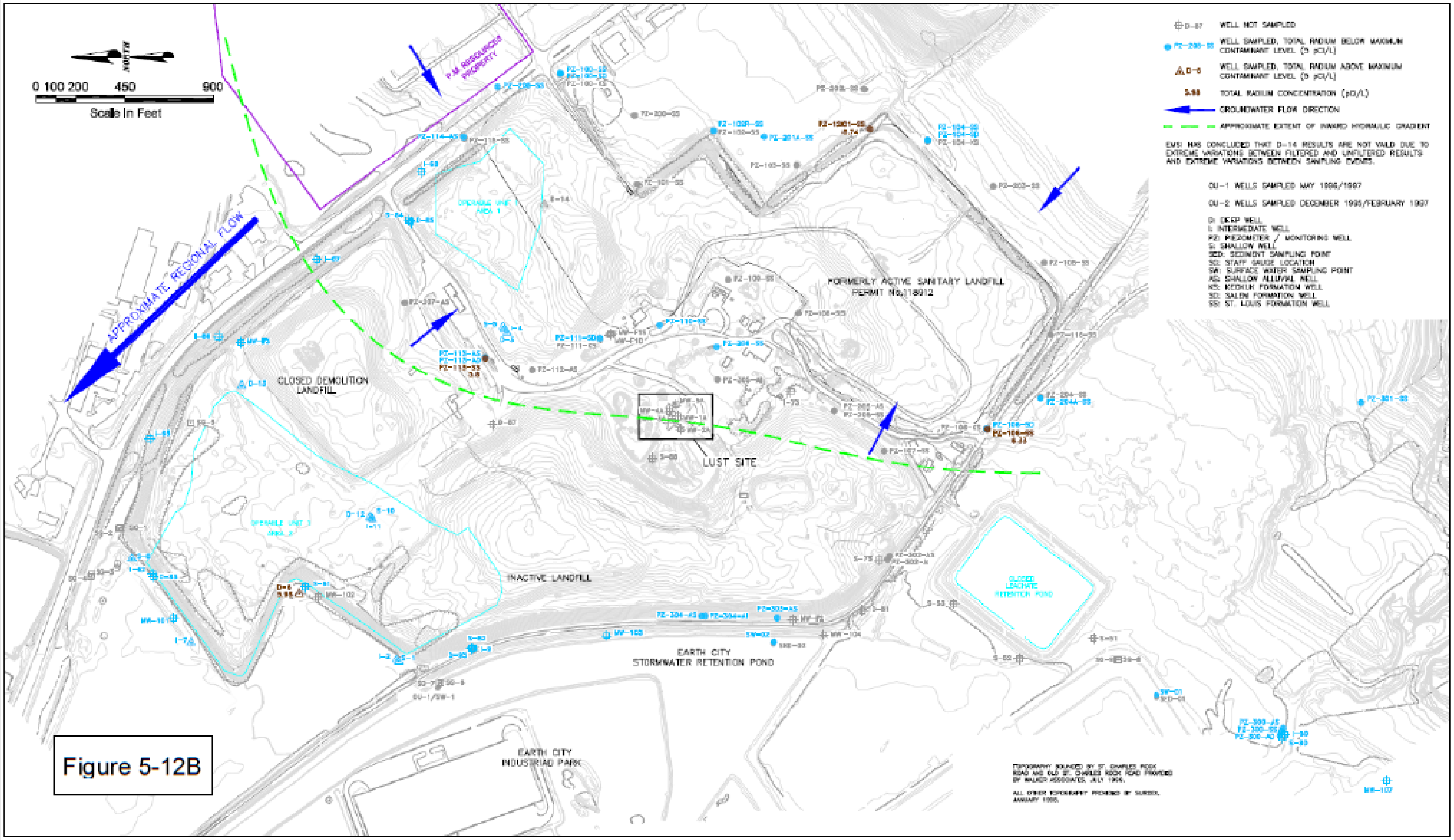


Figure 5-12B

4630 South Highway 94
North Outer Road
St. Charles, Missouri 63304
Phone (636) 939-9111
Fax (636) 939-8787
HERST & ASSOCIATES, INC.®

West Lake Landfill
Bridgeton, Missouri

Groundwater and Surface Water
Total Radium Results